FARM CROPS

BY MANY SPECIALISTS

UNDER THE EDITORSHIP OF

WILLIAM G. R. PATERSON

B.Sc., N.D.A.(Hons.)

Principal and Professor of Agriculture

The West of Scotland Agricultural College

AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE

No. 1574

15 AUG 1927

COIMBATORE

VOLUME IV

MISCELLANEOUS CROPS

1574

THE GRESHAM PUBLISHING COMPANY LTD.

66 Chandos Street, Covent Garden, London

1925

COIMBATORE-3

Printed in Great Britain

CONTENTS

VOLUME IV

Page

ROTATIONS - - - - - - - - - - - - - - 1
By Victor C. Fishwick, P.A.S.I., N.D.A., N.D.D.

ENSILAGE - - - - - - - - - - - - - - 37
By A. W. Oldershaw, M.B.E., B.Sc.(Edin.), N.D.A.

HOPS - - - - - - - - - - - - - - 59
By A. H. Burgess.

DISEASES OF HOPS - - - - - - - - - - - - 83
By E. S. Salmon, F.L.S.

OSIERS AND WILLOWS - - - - - - - - - - - 90
By Henry P. Hutchinson.

THE TOBACCO CROP - - - - - - - - - - - 96
By Joseph Hanly, F.R.C.Sc.I.

HEMP - - - - - - - - - - - - - - 104
By J. Vargas Eyre, M.A., Ph.D., F.I.C.

CHICORY - - - - - - - - - - - - - 109
By W. G. Smith, B.Sc., Ph.D.

BUCKWHEAT - - - - - - - - - - - - 113
By J. G. Stewart, M.A., B.Sc., N.D.A., N.D.D.

MUSTARD - - - - - - - - - - - - - 118
By Fred. A. Smith and W. J. Malden, A.S.I.

Page

LINSEED OR FLAX - - - - - - - - - - - - 123
By F. K. Jackson.

HEATHER - - - - - - - - - - - - - 129
By W. G. Smith, B.Sc., Ph.D.

MISCELLANEOUS CROPS - - - - - - - - - - 135
By W. G. Smith, B.Sc., Ph.D.

LUPINS - - - - - - - - - - - - - - 154
By A. W. Oldershaw, M.B.E., B.Sc.(Edin.), N.D.A.

WEEDS OF ARABLE AND GRASS LAND - - - - - 158
By Professor A. N. M'Alpine, B.Sc.(Lond.), Assoc.R.C.S.

FRUIT AND VEGETABLES - - - - - - - - - 225
By Dudley V Howells, Agric.Dip.(U.C.W.), F.R.H.S.

INDEX - - - - - - - - - - - - - - 309

LIST OF PLATES

	Facing page
REINFORCED CONCRETE SILO	42
THE HOARD SILO	44
HOPS	60

AGRICULTURAL COLLEGE
No. 1574
15 AUG 192
COIMBATO

ROTATIONS

By VICTOR C. FISHWICK, P.A.S.I., N.D.A., N.D.D.

The History of Rotations

If we examine the cropping of any field we shall find that crops are grown upon it in a given sequence and this sequence is repeated periodically. The sequence followed upon any given field is known as a rotation. There may be three, four, five, six, seven, eight, or even more annual courses in a rotation. The cropping of the field in front of my window will illustrate this point. The crops grown upon it for the last twelve years have been:

1924, wheat.	1920, wheat.	1916, wheat.
1923, clover.	1919, clover.	1915, clover.
1922, barley.	1918, barley.	1914, barley.
1921, roots.	1917, roots.	1913, roots.

In this case the sequence, or rotation, is roots, barley, clover, and wheat, and as there are four courses in the rotation it is known as a "four-course rotation".

The practice of alternating crops one with another is very old, and what we might almost describe as a simple rotation was practised by the Saxons. Their arable land, which adjoined the villages, was divided into two, three, or four open fields, one of which was left fallow, that is uncropped, the others being cropped. In order that no man should have all his land fallow in any one year the fields were divided up into strips, and each cultivator had land in each of the fields.

Lord Ernle[1] says: "The Manorial records of the early Normans show that the two-field system was still practised after the Conquest but that the three- and four-field systems were more common. The crops grown were: winter seeds, wheat and rye; spring seeds, barley,

[1] *English Farming, Past and Present.*

oats, peas, beans; and fallow." Little, if any, change was made in the method of cultivating the land through the Middle Ages and the Tudor period, and though the refugees who came to this country from the Continent during the sixteenth and seventeenth centuries brought with them turnips, clover, and grass seeds, these crops were not cultivated to any appreciable extent.

Sir Richard Weston, about 1650, was one of the first to demonstrate the value of turnips and clover as field crops and the economy of systematic farming. Towards the end of the seventeenth century Jethro Tull invented the drill and greatly improved the implements of cultivation. At the commencement of the eighteenth century Lord Townshend, on his estate at Raynham in Norfolk, demonstrated the value of the modern rotation, and the rotation he practised was identical with the Norfolk four courses of to-day. So persistent was Townshend in advocating the extension of the cultivation of turnips that he earned for himself the nickname of " Turnip Townshend ".

But the example and advice of enlightened men like Weston, Tull, and Townshend did but little to improve the farming practice followed in the country as a whole. The principal reason for this was that the greater part of the arable land still existed as open fields. During the sixteenth and seventeenth centuries and the early part of the eighteenth century a few enclosures were made, but these only included a small fraction of the land of the country. In the open fields the system of cultivation employed in the thirteenth century was still in vogue and no improvement was possible. After harvest was cleared the stock of the whole village was turned on to the stubble under the common herdsman. It was therefore useless to cultivate such crops as turnips and clover; to do so was simply to provide fodder for the neighbours' stock, and it was not until a large amount of the land was enclosed at the end of the eighteenth and beginning of the nineteenth centuries that the majority of the farmers of this country adopted the improved practices *advocated by these great pioneers. Between 1750 and 1850 the greater* portion of the land in this country was enclosed. This gave a great impetus to agricultural progress, with the result that the systematic management of arable land advocated by Townshend a hundred years earlier became general, and rotational cropping the basis of English arable husbandry. During the nineteenth century Townshend's rotation, now known as the " Norfolk four-course rotation ", was copied and improved upon, and numerous other rotations were introduced to meet the varying requirements of different localities, and to-day a large number of different rotations are employed in this country.

During the latter half of the nineteenth century so much importance was attached to rotational cropping that upon many well managed estates it was customary to insert a clause in all farm agreements binding the

farmer to farm his arable land on a given rotation of crops. Such a clause was valuable from the landlord's point of view, but the fluctuations of the market made it difficult to secure the maximum profit by adhering to a rigid system, and a strong feeling arose amongst tenant farmers against such restrictive covenants, with the result that the landlords' powers were curtailed by the Agricultural Holdings Act of 1908.[1] Since the passing of this Act the tenant has complete freedom to crop the land in any way he likes *except during the last year of the tenancy*. But in spite of the fact that farmers are no longer bound by their agreements to farm their land on any particular system, rotations are practised on the majority of the farms in this country at the present day.

Considerations Affecting the Choice of Crops

There are several factors which have to he considered in deciding what crops shall be grown on a farm, and we will now deal with the most important of them.

The labour bill is one of the most serious items of the farmer's expenditure, and unless his labour is managed with skill and economy, it will quickly eat up all the profits and leave him with a loss at the end of the year. It is very essential that horses, implements, and men should be kept fully employed, and as regards men it must also be remembered that those employed regularly are more economical and do better work than casual labourers.

If one or two crops only were grown, the work of the farm would be concentrated into certain periods of the year, and at these periods a comparatively large amount of labour would be required. For instance, on some of the American farms where wheat is the only product, a considerable amount of labour is required to prepare the land and sow the seed in the spring, and again in the late summer for harvesting, but between seed time and harvest there is little, if any, labour required on the arable land.

On the other hand, by growing a number of crops which are sown and harvested at different times in the year the work on the arable land can be distributed over the whole year. Thus by growing winter corn, spring corn, and roots, seed time is divided into three portions which occupy three different periods of the year, whilst harvest will be divided into two—the corn being ripe at the end of the summer, but the roots not being ready to lift until the autumn. Between these periods the vacant land can be cultivated and prepared for cropping, and practically throughout the year there is work to be done on the arable land.

At the same time, the supply of agricultural labour is distinctly

[1] Section 26.

limited, and in spite of the great strides which have been made in labour-saving machinery, a larger amount of labour is required for handling certain crops than others. Grain crops and hay can be handled with a smaller staff than can roots and market garden crops, and the area that can be planted with the latter is frequently limited by the amount of labour available.

The grazing season, which rarely commences before April or extends later than October, provides food for stock for only five months, and in some seasons does not suffice for that period. A great proportion of the food required during the remainder of the year is produced on most farms on the arable land. For this purpose roots and cabbages are grown, and these must be supplemented with fodder and grain or cake; thus the cropping of the arable land will be governed to a certain extent by the amount and the type of stock kept upon the farm.

As a general rule some of the produce of the arable land will be sold, and the crops most suitable for feeding at home are not always the best for placing on the market. There are two factors which should be considered in deciding which crops shall be grown for sale.

First is the proximity of markets. On farms situated close to large manufacturing centres or near a railway or wharf, bulky crops like potatoes and other market garden produce can be profitably grown, whilst the difficulty of transport usually prohibits their growth on farms situated in the more remote rural districts. The development of motor transport may, however, in the near future, place farms situated at considerable distances from their market centres in a better position in this respect.

The second factor is the comparative market value of the different crops; this point is well illustrated in the root crop. Swedes, turnips, and mangels, the principal roots grown for stock, as a rule command but a small price on the market, whereas potatoes not only as a rule make a good price but can be easily disposed of, and therefore instead of growing swedes, turnips, or mangels to place on the market the farmer usually grows potatoes.

It will be seen then that the farmer cannot concentrate his attention upon the production of one or two crops, but must grow a variety in order (1) to distribute the work to be done on the arable land as evenly as possible over the whole year and thus enable him to use his labour economically, (2) to provide suitable food for his stock, (3) to market his surplus produce to the best advantage.

Soil and climate must also be taken into consideration. Heavy clay soils require handling with great skill and care. Very little cultivation can be done in the winter months, and thus the fine tilth necessary for barley is very rarely obtainable. On this type of land, therefore, this crop is but little grown, and oats, which do not require such a fine tilth,

usually follow roots. Wheat and beans do well on it, and heavy land is often described as wheat and bean land. Winter folding is impossible. Sheep would not only get into a pitiable state owing to the amount of soil that would adhere to their bellies and legs, but would do a considerable amount of harm by treading and puddling the clay after the autumnal rains had made the land wet. Any roots which are grown must be carted off the land early, before it gets really wet, or much damage would be done to the mechanical condition of the soil owing to the puddling of the clay by the cart wheels and horses' hoofs. The root area is therefore generally comparatively small. Potatoes do not as a rule do well, and mangolds and swedes are the principal roots grown. Vetches and clover will crop well if the land is properly drained.

On loam most crops can be grown successfully.

Light land does not as a rule produce heavy crops of wheat, beans, or mangolds. It needs consolidation, and this can be done in no more economical or satisfactory way than by sheep, which it will carry at any time in the year. Crops which can be folded on the land are therefore very useful, and as turnips grow well the area under this crop is comparatively large. Of the cereals, barley is the most important. Peas often do well and are generally grown in preference to beans; red clover and vetches do not thrive, but trifolium and sainfoin are largely grown on light soils which contain sufficient carbonate of lime. Catch crops are very useful on both loams and the lighter classes of land, provided the rainfall is sufficiently high.

On peaty soils potatoes are the principal crop. Mangolds and turnips will grow to a great size but are of low feeding value and frequently hollow. Rape is the most useful forage crop and kohl-rabi is often grown. Owing to the excess of nitrogen in this class of soil, the straw of cereals is liable to be heavy and weak, resulting in the lodging of the crop before harvest. This not only decreases the produce of grain but increases the difficulty of harvesting the crop. Excellent crops of some of the stiffer strawed varieties of wheat can, however, sometimes be produced.

It must not be inferred that no other crops than those mentioned can be grown on the various types of soils. Other crops can be grown and often are, but those mentioned are the ones most commonly cultivated.

With regard to climate, generally the deep rooting crops resist drought better than those whose roots do not penetrate so deeply. Thus wheat and mangolds when once established do well in a dry climate; barley needs a fair amount of moisture during its growth, but dry weather is very desirable at harvest if the grain is to be sold for malting. Oats do well in a moist climate. Red clover, trifolium, vetches, beans, and peas, although deep rooting, make their maximum growth when liberally supplied with moisture, but fine weather is essential at hay-time with

all leguminous forage crops, whilst the harvesting of peas is a difficult matter in showery weather. Lucerne and sainfoin when once established flourish in a dry climate. Kohl-rabi can resist drought. Turnips, swedes, and potatoes make their best growth in a moist climate.

Many of the most valuable pasture plants thrive best when well supplied with moisture. Thus in wet districts leys, as a rule, occupy a larger proportion of the arable than in dry districts. In wet districts long leys, that is to say leys which are left down for two, three, or four years, are popular, one-year leys being rarely met with, whereas in dry regions one-year leys are common and longer leys rarely met with.

Another factor which must be borne in mind in deciding what crops shall be grown is their effect upon the soil.

Only a small amount of cultivation is given to land which is being prepared for white straw crops, and after-cultivation is restricted to harrowing and rolling. Thus under these crops weeds tend to accumulate and the texture of the soil tends to deteriorate.

The effect of clover and rotation grasses depends to a very great extent upon the thickness of the crop. If a good plant is obtained the crop will effectually smother weeds, but these quickly establish themselves in the gaps between the plants in a thin crop. Thus a good crop of seeds leaves the land clean whilst a poor one leaves it foul. There is no opportunity for cultivating land which is under seeds, thus the mechanical condition of the land deteriorates slightly. This deterioration is, however, balanced by the effect of the large amount of humus left in the soil, and as a rule an old seeds ley will " work " well.

Peas are apt to leave the land foul and in poor mechanical condition, but as a rule they are harvested early and there is time to take a short bastard fallow after the crop has been harvested. Beans when grown in wide rows can be hoed until late in the season, and after them the land is often clean and in good condition, but when grown in narrow rows hoeing must stop early. Thus the land is often left foul and in poor condition.

FALLOWS

When land is left uncropped we have what is known as a " fallow ". If it is left bare for the whole winter we have a " winter fallow "; if uncropped for a whole summer we have a " summer fallow "; and when no crop is taken for a whole year the term " bare fallow " is used. The name " bastard fallow " is used to describe a very short fallow. Roots, cabbage, and similar green crops are often referred to as fallow crops. The land receives very thorough cultivation when the seed bed is being prepared for fallow crops; these crops receive a considerable amount of after-cultivation, and as a rule they leave the land clean and in good mechanical condition.

Land which is under fallow usually receives a certain amount of cultivation which is carried out with a view to cleaning the land, and in the case of medium and heavy land to improving its mechanical condition.

When land is under a winter fallow, cleaning is sometimes possible in the autumn if the weather is sufficiently dry, but the principal cleaning operations are as a rule done in the spring when the seed bed is being prepared for the succeeding crop. The great advantage of a winter fallow lies, however, in the improvement effected in the mechanical condition of medium and heavy soils. This improvement is caused by the action of the weathering agents, and the land should therefore be ploughed in the autumn and left for the winter in the furrow, or ridged up, as in this condition these agents can act upon it to the maximum extent. The amount of benefit which accrues from a winter fallow depends entirely upon the weather. Frost is a very active agent for improving the mechanical condition of the soil, and a large amount of good is done by alternately wetting and drying the soil. Thus in a hard winter, or one in which the wet weather is alternated with dry windy spells in which the soil dries to a certain extent, the " condition " of the soil is improved; on the other hand, in a continuously wet winter the benefit of a winter fallow is reduced to a minimum.

When land is under a summer fallow a considerable improvement can be effected in the mechanical condition of medium and heavy land. The improvement is produced principally by alternate wetting and drying and the maximum effect is produced in showery weather. The great advantage of a summer fallow, however, lies in the opportunity it affords of cleaning the land. This can be done most effectively in a dry season. In a prolonged spell of dry weather it is only necessary to keep the soil stirred deeply so that it dries out and weeds are killed from lack of moisture. In a wet season the land can be cleaned but more work is involved. In this case stirring the land during the summer will usually produce a certain amount of fine mould, and conditions are very favourable for the germination of weed seeds, and if ploughed land is left uncropped for any length of time a large number of weeds will establish themselves. If, however, the land is ploughed at convenient intervals, or stirred with a thistle plough, broadshare, or even a cultivator fitted with broad feet, large quantities of weed seedlings will be cut up and destroyed. It is usually necessary to harrow after ploughing, and so drag to the surface the plants which have been cut, and thus prevent them taking root again. During the summer months the temperature is comparatively high and, as fallow land is kept stirred and well supplied with air, nitrification takes place rapidly. There being no crop to remove the nitrates formed, these accumulate in the ground and are available for the succeeding crop. The extent to which the following crop

benefits from this store of available plant food has been studied at Rothamsted, where two plots have now been alternately cropped with wheat and fallowed for over sixty years. Table IA shows how the yield from this land compared with that of the continuous wheat plot on Broadbalk field.

TABLE IA

Broadbalk Field, continuous Wheat.		Hoos Field, alternate Wheat and Fallow.	
Average Yield for 57 Years.		Average Yield for 57 Years.	
Grain.	Straw.	Grain.	Straw.
12·2 bush.	9·8 cwt.	16·0 bush.	13·7 cwt.

It will be seen that the yield after the fallow is considerably greater than that on the land which carries a crop continuously. Hall and Russell [1] point out that the amount of benefit which the following crop derives from the nitrates stored up during a fallow, depends upon the weather during the autumn months. If this is very wet a large portion of the nitrates formed during the summer will be washed out and the benefit derived from a summer fallow is reduced to a minimum; *it is only when the autumn and winter are dry that the full benefit is derived from a summer fallow.*

A bare fallow combines the advantages of a winter and a summer fallow. It is, however, a rather wasteful practice as a large amount of money is expended upon cultivation, rent, &c., without obtaining any crop, and at the present time bare fallows are only met with to any appreciable extent on very heavy land.

Fallow crops find their place in most systems of cropping. Bare fallows are but little practised in the west and north of this island but are a typical feature of the cultivation of some of the heavier land in the midland, eastern, and south-eastern counties.[2] In all parts of the country a summer fallow is often taken as a special measure upon land which has been allowed to get very foul. A bastard fallow is often taken after a crop such as peas or tares and oats, which is harvested early in the summer. This is a very economical method of cleaning land and restoring its condition.

It will be seen that the cropping of the farm is governed by (1) the labour available and its economical management, (2) the requirements of stock, (3) the proximity and requirements of markets, (4) the soil of the farm, (5) the climate of the locality, and (6) the effect of the crops upon the soil.

[1] *The Rothamsted Experiments* (1917 edition), p. 63.
[2] Examples of rotations which include a bare fallow will be found on pp. 17, 27, and 29.

The Principles upon which Rotations are Founded

We have already seen that the farmer will usually need to grow a variety of crops. We may now consider the factors which govern the arrangement of these crops upon the farm.

The autumn months are very busy months on the arable land. The autumn corn must be drilled, and on the heavier types of land this must be done as early as possible; roots that are to be stored must be lifted before the hard frosts set in, whilst as much land as possible should be ploughed so that it may get the full advantage of the winter frosts. It is thus a matter of considerable importance that the work of preparing the land for the autumn corn should be reduced to the minimum. Land which has been under a summer fallow is ready for seeding; land which has carried a bean crop is fairly clean and in good heart and can be quickly prepared. It is obviously then convenient and economical to plant the autumn grain on land which has carried beans or been under summer fallow. The spring-sown corn crops require a good tilth. The better the mechanical condition of the soil, the easier it is to produce a tilth, and as the land which has been under roots and other fallow crops will be in better mechanical condition than any other land on the farm, a considerable amount of labour may be saved in cultivation by using the old root land for the succeeding crop of spring corn.

It will be seen then that among the factors which govern the arrangement of the crops upon the farm are convenience and economy in cultivating the land.

When considering the cultivation of the crops grown on the farm it will be observed that under certain crops, such as wheat, the mechanical condition of the soil deteriorates, and that under others, which we may term renovating crops, it improves. If crops of the former type are grown for a succession of years upon the same land, the soil will fall off in condition, and after a time it will become very difficult to prepare a seedbed. This loss of condition, however, can be avoided to a very great extent by growing a renovating crop after one which permits deterioration. At the same time this alternation cannot be done promiscuously or the areas under certain crops may become inconveniently large or small, but by following a carefully thought out order of cropping it is possible to obtain the necessary sequence and at the same time keep the areas under the various types of crops within the required limits year by year. Thus the next factor which governs the arrangement of the crops on the farm is the efficient cultivation of the soil.

Intimately associated with the question of cultivation is that of

cleaning the land. A full crop cannot be obtained from foul land, and if weeds are once allowed to establish themselves the work of eradicating them is tedious and expensive. It is thus very important that as far as possible the cropping shall be arranged in such a way that weeds are kept in check. In this respect two factors must be borne in mind. In the first place certain weeds grow more readily under one type of crop than under others, and disappear if that type is changed. A good example of this is to be seen at Rothamsted,[1] where, on the plots carrying wheat continuously, the Black Bent (*Alopecurus agrestis*), a troublesome weed on corn land, can only be kept in check with very great difficulty, but this weed rarely appears upon the adjoining land where a rotation is followed. The second point to be borne in mind is the fact that under some crops the land grows foul whilst under others it is cleaned, and so, by alternating fouling crops with cleaning crops, weeds may be prevented from establishing themselves. It will thus be seen that the cleaning of the soil is facilitated by changing the type of crop grown on the land each year—fouling crops followed by cleaning crops or fallow. This is the third factor to be borne in mind in arranging a sequence of cropping.

Turning now to the question of manuring, some crops such as roots respond readily to dressings of farmyard manure, whilst others, such as barley, give a better result from the residue of the manure applied to a previous crop. It is obviously economical to concentrate the farmyard manure upon the crops which pay best for its direct application and to follow them by crops like barley—withholding the dung from these. Wheat is very dependent upon the supplies of nitrogen available in the soil, therefore, by growing wheat after a leguminous crop, which leaves the ground rich in this element, the nitrogenous dressing may be greatly reduced if not dispensed with altogether.

It must also be remembered that the roots of the different varieties of crops penetrate to different depths—wheat, beans, and mangolds being deep rooting, barley, oats, and turnips shallow rooting—and it is desirable to grow a number of crops upon the land with as wide a root range as possible in order that the stores of plant food in the soil may be utilized to the greatest possible extent. Only one variety of crop can as a rule be grown at once, but the object may be attained by growing the necessary crops in succession.

The fourth factor which governs the arrangement of crops on the farm is economy in manure and the efficient utilization of the stores of plant food in the soil.

For a long time it has been recognized that a crop grows with exceptional vigour when planted upon land that has not carried that particular crop for a long time, and that some crops when grown in

[1] *Rothamsted Experiments*, by Hall and Russell, Chap. IV.

a rotation are more healthy and vigorous than when grown continuously on the same land. Early in last century De Candolle suggested that this was due to the fact that the roots of plants excreted products which were toxic to themselves, and this theory has been revived and extended by Whitney and Cameron in America in recent years. Russell[1] has been unable to find any lasting toxic effect, with any of the crops he has studied, and considers that the toxin hypothesis as an explanation of the advantages of a rotation must be ruled out.

Crops are liable to be attacked by a number of diseases which, before their causes were understood, were described by the common term blight. We know them now to be due to the attacks of insects, fungi, and bacteria. Some insects such as wireworm attack almost any crop, but the majority of insects, fungi, and bacteria confine their ravages to one kind of plant only, or at the most to the members of some particular natural order. Many of the insects hibernate in the top layer of the soil and on debris from the attacked crops; and after an attack of a fungus the soil is usually badly infected with the disease.

If the following crop be susceptible it will be attacked, but if a different crop be grown which is immune to the particular pest, the insects, &c., will in time die out. The length of time such pests retain their vitality varies; in some cases an interval of two years is sufficient, whilst in others, such as clover sickness, seven years or more should be allowed before a susceptible crop is again grown.

It will be seen therefore that in order to keep insect and fungous pests down, as long an interval as possible should be allowed between crops liable to attacks of the same diseases.

In a carefully thought out rotation all the above factors are taken into consideration, and we may say that the principles which underlie rotational cropping are:

1. Convenience and economy in cultivating the land.
2. The efficient cultivation of the soil.
3. Clean farming.
4. Economy in manure and the efficient utilization of the stores of plant food in the soil.
5. Prevention of attacks from insects, fungi, and bacteria.

Continuous Cropping: Two-, Three-, and Four-course Rotations

A study of the previous pages will show that rotational cropping has many advantages, but it may be noted in passing that continuous

[1] *Soil Conditions and Plant Growth,* Sir E. J. Russell, p. 246.

cropping is practised. Perhaps the most notable instance of it is the custom of leaving land down to permanent pasture. Even on arable land continuous cropping is occasionally seen. On the virgin soils of America wheat is often grown continuously, while even in this country, where a conservative system of farming is followed, cases of continuous cropping are sometimes met. For instance, on the coast of Ayrshire certain fields are to be found that are particularly suitable for early potatoes, and on some of these this crop has been produced continuously for the past twenty years. Again, on some grass farms which include only a very small area of arable land, this is sometimes cropped continuously with mangolds to provide succulent winter fodder for the stock. In the case of both potatoes and mangolds, however, there is a long interval between harvest and seed-time during which the land can be very thoroughly cultivated, both crops can make economical use of liberal supplies of farmyard manure, and their continuous cultivation need not cause any loss of fertility or condition to the soil; further, mangolds are peculiar in their freedom from disease.

Two-course rotations are not common, but a practice that might almost be described as a two-course rotation is usual in some parts of America in which lucerne, there known as alfalfa, and wheat are the staple crops. Under this system wheat is grown continuously for a period of years, at the end of which the land is put down to lucerne, which is left for several years then ploughed up and the land again cropped with wheat.

The three-field system which was practised in this country through the middle centuries has already been mentioned, but the majority of rotations that are in use in this country at the present day contain from four to eight annual courses, and we will now study a few typical examples of these in detail. There are, of course, a large number of rotations in use, which space will not permit us to deal with.

The arable land is usually divided into sections, the number of sections corresponding with the number of courses in the rotation followed, and as no two sections are under the same course in any one year the whole rotation is represented on the farm each year. For instance, with the Norfolk four-course rotation, the courses of which are roots, barley, clover, and wheat, the land is divided into four sections and each year one section is under roots, one under barley, one under clover, and one under wheat. The area of all of the sections need not be the same, but it is a convenience if they are fairly uniform in size.

On many well managed farms a detailed record is kept of the way each field is cropped year by year. A very convenient method of keeping this record is in the form adopted to show the typical schemes of cropping under the various rotations. Table IV, opposite p. 34, shows an extract from a crop record kept on this system.

The oldest of the modern rotations is the Norfolk four-course; it is still extensively followed on light soils.

TABLE IB

Showing Cropping of a Farm under the Norfolk Four-course Rotation for Four Years (1921 to 1924)

Section.	1921.	1922.	1923.	1924.
1	Wheat.	Roots.	Barley.	Clover.
2	Roots.	Barley.	Clover.	Wheat.
3	Barley.	Clover.	Wheat.	Roots.
4	Clover.	Wheat.	Roots.	Barley.

Upon large arable farms, well equipped with buildings and at some distance from a market, it is convenient to use a large proportion of the produce of the arable land for fattening stock. The root crop consists mainly of swedes and turnips, a portion of which is folded upon the land, and the remainder used for feeding to stock in yards, large quantities of farmyard manure being produced. The foregoing system is common in Norfolk and the adjoining counties and also in the north. In the midland and southern counties dairying and stock-rearing are popular. Where these are carried on, mangolds and very often cabbage and kale are grown in addition to swede turnips. Upon the Chiltern Hills, the Cotswold Hills, and the North and South Downs many of the farms are not well equipped with buildings. In such cases the whole of the root crop is usually folded off by sheep, and little if any farmyard manure is made. In this case the root area often includes rape, cabbage, kale, swedes, and turnips sown so as to provide a succession of succulent fodder.

With regard to clover, on most land Red Clover cannot be safely cultivated more frequently than once every seven years and it is therefore grown once in eight years only, the other clover break being filled by Alsike, White Clover, Trefoil, or other leguminous crop or sometimes by a mixture of clovers and grasses.

Manuring.—All the farmyard manure is usually applied to the land which is under preparation for the root crop, and upon good land this is often supplemented by artificials. On farms where little or no farmyard manure is produced the root crop usually receives a liberal dressing of artificials and practically the whole crop is fed on the land. At Cockle Park Experiment Station[1] in Northumberland good results have been

[1] *Guide to Cockle Park Experiment Station* (Armstrong College, Newcastle), pp. 7–8.

obtained by applying farmyard manure alone to the roots and giving the seeds a dressing of basic slag and muriate of potash. In marked contrast to the foregoing custom we find that in parts of the south-west of Scotland the root crop is grown entirely with artificials and the farmyard manure is applied to the grassland. Generally in the Midlands and south of England no other manure is applied during the rotation except to the wheat crop; the practice of applying a nitrogenous top-dressing to wheat in the spring is becoming more and more general. Much may be learned regarding the requirements of land farmed on a four-course rotation from the Agdell Field rotation experiment at Rothamsted.[1] From the data accumulated there, Hall and Russell drew the following conclusions: "The losses of nitrogen on strong land farmed on a four-course system are almost made up by the growth of a crop of clover, and will be more than repaired by a dressing of 15 tons of farmyard manure or its equivalent during the rotation. The losses of phosphoric acid and potash would be similarly made up, though it is well also to use about 50 lb.[2] of phosphoric acid per acre for the swede crop, which is especially dependent upon available phosphoric acid.

"As the standard of farming is raised, however, it is necessary to give further supplies of nitrogen and corresponding increases in supplies of phosphates and potash."

Wheat is drilled in autumn, barley and clover in the spring, and roots in the spring or summer. Wheat and barley are harvested in August and September, clover in June or early July and the second cut in August, while turnips are folded or pulled in the autumn and winter; thus the labour on the arable land is distributed over the whole year. Wheat leaves the land foul and in poor mechanical condition, but the turnips which follow are not planted until the succeeding summer, leaving a long interval in which the necessary cultivations can be done as is most convenient. As has already been pointed out, the land which has carried turnips can be most economically and conveniently prepared for barley, and barley is a suitable nurse crop for clover.

A fallow crop, roots, being taken once in every four years, the mechanical condition of the soil is maintained and the land is kept clean.

Wheat following clover, and barley following roots, will require no farmyard manure, so that the bulk of this manure available may be concentrated on the roots which respond readily to its action, and as the wheat crop follows clover, the nitrogenous top-dressing for this crop is reduced to a minimum.

Two deep- and two shallow-rooting crops are grown in each period of four years.

[1] *Rothamsted Experiments* (Hall and Russell), Chap. X.
[2] 50 lb. phosphoric = 109 lb. calcium phosphate.

In the original form of the rotation only four years elapse between successive crops of roots and clover, and this is not a sufficiently long interval to keep finger-and-toe in turnips or the sickness in clover in check. But on farms where both mangolds and turnips are grown, if care is taken to plant the turnips on the land previously cropped with mangolds [1] and vice versa, an interval of eight years elapses between two successive turnip crops. Thus as previously pointed out an interval of eight years can be obtained between two successive Red Clover crops, and where this is done the rotation conforms to the five basic principles enunciated in the preceding chapter.

It is very important that light soils should be liberally supplied with organic matter, as their clay content is small and their water retaining capacity is therefore very largely dependent upon the amount of organic matter they contain. Folding with sheep is a very important item in the management of these soils, as not only do the droppings of the sheep increase the supply of organic matter but the treading of the sheep consolidates the soil. Consolidation is important on light land for two reasons. In these soils organic matter is oxidized rapidly as they are porous and well supplied with air, but the firmer the soil the less rapid is oxidation; at the same time water can be raised more readily from the lower layers in a firm soil than in a loose open one; [2] thus by consolidating light soils their power of resisting drought is increased.

With the Norfolk four-course rotation half the land is annually under white-straw crops, and, although the straw grown on light land is usually short in length, a large amount of straw is produced each year which can be turned into farmyard manure in the homestead, and returned to the land to maintain the store of organic matter in the soil. The large area devoted to roots enables a large number of sheep to be folded on the land, and provides a surplus for the use of yard-fed stock.

The saleable products from farms worked on this rotation are wheat, barley, clover hay, clover seed, fat cattle and sheep. With the exception of clover hay, which can be consumed on the farm, these are all easily conveyed to their market, and this rotation is therefore suitable for farms situated a long distance from a market.

This rotation may be subjected to considerable variation without altering the framework; for example, oats may be substituted for part or all of the wheat or barley, and peas may be grown instead of part of the clover.

The winter fallow which precedes the turnip crop is not essential on land that is clean as, owing to the small amount of clay in light soils, there is very little, if any, deterioration in mechanical condition, whilst there is a considerable loss of soluble plant food if such soils are left

[1] Some claim that this really makes it into an eight-course rotation.
[2] *The Soil*, by Sir A. D. Hall, Chap. III.

uncropped in wet weather. On land that is clean and in good heart catch crops may therefore be profitably introduced into the Norfolk four-course rotation in districts where the rainfall is sufficiently high, the sequence then being:

1st year	..	..	Catch crops—Rye, Winter Barley, Trifolium, &c., followed by short bastard fallow followed by roots.
2nd year	..	..	Barley.
3rd year	..	..	Clover.
4th year	..	..	Wheat.

By growing a variety of catch crops green fodder may be produced from May to August, those which are cleared first being followed by cabbages and swedes and those cleared later in the summer being succeeded by turnips.

This variation is very valuable on arable farms as it gives greater latitude in stocking. With the typical Norfolk four-course, turnips and swedes are the only succulent forage crops grown and these must be fed in autumn, winter, and early spring, and unless a fair area of grass is attached to the arable land, stock cannot be kept during the late spring and summer, and thus the farmer is restricted to winter feeding and must purchase stores, both sheep and cattle, in the autumn for this purpose. When catch crops are grown, however, a succession of fodder is produced to follow on after the swedes have been finished, and stock can be kept all the year round. Thus a breeding flock or a dairy herd may be maintained if desired on farms which are mainly arable; and even on mixed farms the succession of green fodder produced by the catch crops in spring and early summer is very useful for ewes and lambs.

There is another four-course rotation in use principally on sheep farms in parts of the south of England where the rainfall is fairly abundant—on land which is light but not naturally rich in plant food—which makes a considerable use of catch crops, and the sequence is:

1st course	..	..	Catch crops folded off, followed by a short bastard fallow, followed by turnips folded off.
2nd course	..	..	Spring corn.
3rd course	..	..	Catch crops, followed by rape (folded off).
4th course	..	..	Winter corn.

The catch crops in the first course are usually Winter Rye, Winter Barley, &c., and are not manured, and the turnips which follow receive any farmyard manure that is made on the holding (on many farms very little farmyard manure is made), often supplemented by artificials. Either wheat, barley, or oats may be grown in the second course, no manure being applied. Leguminous plants are usually selected for the

catch crops in the third course, the rape which follows not being manured. Either wheat or oats may be grown in the fourth course, also without manure.

By selecting catch crops carefully and using care and judgment in choosing the time of sowing, this rotation will provide abundant supplies of succulent fodder all the year round and is hence very valuable on sheep-breeding farms.

Some of the light sandy soils containing only small quantities of lime produce only poor crops of clover and wheat, but will, however, grow potatoes if liberally manured, and produce excellent barley. On such soils in Bedfordshire a four-course rotation which includes two barley crops is very popular, the sequence being:

1st course ..	Roots.	3rd course ..	Potatoes.
2nd course ..	Barley.	4th course ..	Barley.

Turnips and swedes are the roots usually grown, and receive about half the available farmyard manure, and this is usually supplemented by artificials. The remainder of the farmyard manure is applied to the potatoes, which also as a rule receive artificials. The barley is not manured.

On these soils this rotation is quite useful, as barley of high quality is produced and a good yield is usually obtained, and potatoes are also a profitable crop. It, however, necessitates the production of a large quantity of farmyard manure or the purchase of town manure and requires a large staff of labour to work it, as half the land is under roots and potatoes each year.

On the heavier types of land four-course rotations are very rarely practised. On such land roots cannot he folded after the autumnal rains have set in, nor is it desirable to cart roots off the land after it has become wet, as the treading of the horses and pressure of the cart-wheels would, by puddling the clay, do considerable damage, and it is therefore inconvenient to have such a large area under roots as is usually the case with most of the four-course rotations. On the very heaviest types of clay land in the midland and eastern counties a four-course rotation is occasionally practised which includes no roots, wheat and beans being the only products. The sequence followed is:

1st course ..	Bare fallow.	3rd course ..	Beans.
2nd course ..	Wheat.	4th course ..	Wheat.

A dressing of farmyard manure is given to the land under preparation for beans, and occasionally the fallow also receives a light dressing of this manure.

This rotation has a certain amount of value on the very heaviest types of land but is rather wasteful, as the land is uncropped once in four years.

Another weakness is that it produces no succulent winter fodder, and this is a great disadvantage, because on heavy soil a certain amount of yard feeding is very necessary as organic matter is as essential to this type as it is to light land.

Generally speaking, four-course rotations are most suitable for light land, in the management of which they are very valuable, owing to the fact that they enable the land to be folded with sheep at comparatively short intervals.

In the south of Scotland the following rotation is occasionally used upon land which is suitable for the production of early potatoes:

1st course	..	..	Early potatoes.
2nd course	..	..	Wheat.
3rd course	..	..	Seeds ley.
4th course	..	..	Oats or early potatoes.

Five-course Rotation

Some of the lighter types of soil, if not too rich in nitrogen, will grow barley of high quality. If, however, the supply of available nitrogen in the soil is comparatively large, a coarse sample will be produced. On land of this kind a crop of wheat or oats is frequently grown immediately before the barley, and these reduce the amount of available nitrogen in the soil, with the result that barley of good quality is obtained. In the eastern and east-midland counties a five-course rotation is frequently employed which is based on this principle, the sequence followed being:

1st course	..	..	..	Fallow crops.
2nd course	..	..	..	Wheat.
3rd course	..	..	..	Barley.
4th course	..	..	..	Clover or seeds.
5th course	..	..	..	Wheat or oats.

A light dressing of farmyard manure is often given to the young seeds after the barley has been harvested, the remainder of this manure being applied to the roots, which also receive a dressing of artificials. The wheat in the fifth course may be top-dressed with a nitrogenous manure if the seeds mixture does not produce a fair portion of clover. Turnips, swedes, and cabbage occupy the greater portion of the area allocated to fallow crops, but green forage crops are also frequently grown as these not only require less labour but are used slightly earlier than roots, and this enables the wheat following to be sown earlier.

A somewhat smaller area is under roots and a greater area under corn each year than is the case with the Norfolk four-course, as with a five-course rotation the land is typically divided into five sections instead of four.

TABLE II

Showing Cropping of Farm from 1920 to 1924, worked on a Five-course Rotation

Section.	1920.	1921.	1922.	1923.	1924.
1	Fallow crops.	Wheat.	Barley.	Clover or seeds.	Wheat or oats.
2	Wheat.	Barley.	Clover or seeds.	Wheat or oats.	Fallow crops.
3	Barley.	Clover or seeds.	Wheat or oats.	Fallow crops.	Wheat.
4	Clover or seeds.	Wheat or oats.	Fallow crops.	Wheat.	Barley.
5	Wheat or oats.	Fallow crops.	Wheat.	Barley.	Clover or seeds.

In Yorkshire a very similar rotation is common, but the land being naturally less fertile the seeds are taken in the third course, wheat or oats in the fourth, and barley, often manured with phosphates, in the fifth course.

In the counties on both sides of the Scottish border a rotation is followed which is known in some places as the Berwick and in others as the Northumberland five-course rotation. The soils upon which this rotation is chiefly practised are loams of the heavier type and clays of the lighter type. The climate of this district is rather wet, and the winters are longer and summers shorter and cooler than those of the more southern parts of the island. This rotation may be regarded as an extension of the Norfolk four-course, the clover break in the latter rotation being replaced by seeds which are left down for two years. The sequence followed is:

1st course	Roots.
2nd course	Barley or oats.
3rd course	Seeds.
4th course	Seeds.
5th course	Wheat or oats.

Sheep form an important part of the stock of many of the border farms, and the root area generally consists of about equal portions of swedes and turnips. The seeds mixtures consist chiefly of plants which will stand for two years. Oats are more extensively grown than either barley or wheat.

Farmyard manure is applied to the root crop, which as a rule also

receives a liberal dressing of artificials, and usually no other manure is applied during the rotation unless a nitrogenous top dressing is necessary for the wheat in the fifth year. A considerable portion of the roots is folded, the remainder being carted off for the use of the yard-fed stock. The seeds are usually cut once for hay during the first year and subsequently grazed.

This rotation is fairly economical in labour, as only one-fifth of the land is under roots and two-fifths under corn each year, the remaining two-fifths being under grass, for which practically no tillage operations are necessary. The root crop provides abundant succulent fodder for the winter months, whilst a cut of hay is obtained to supplement the straw, and at the same time an area of grazing is provided for the use of the stock during the summer months; considerable latitude is thus given in stocking the farm—either fattening, breeding, or dairying can be carried on.

The saleable products of the farm are wheat, barley, oats, and live stock, all of which can be comparatively easily transported, so that this rotation is suitable for farms situated some distance from a market.

In the south-west of Scotland a common rotation is:

1st course	Roots.
2nd course	Oats (occasionally barley or wheat).
3rd course	First year seeds (cut for hay).
4th course	Second year seeds (grazed).
5th course	Oats.

In this area but few sheep are kept, and the roots consist mainly of swedes which are drawn off for the yard-fed stock.

The roots usually receive both farmyard manure and artificials, and a dressing of artificials is often applied to the seeds in the third course, whilst on poor land the oats (fifth course) sometimes also receive a dressing of artificials.

The rotations which we have up to now examined have all been based upon the consumption of the root crop at home, and the conversion of the straw into farmyard manure, which is applied to the soil. We may now examine a rotation designed to enable nearly the whole of the produce of the arable land to be sold off the farm.

In the industrial districts of South Lancashire a number of fairly large towns are crowded together, and there is a good demand for the bulky products of the farm, such as potatoes, hay, and straw, and farms situated in close proximity to these towns can dispose of the produce at a comparatively high price and without incurring much expense in carriage. At the same time large quantities of house refuse are available for use as manure. Under such circumstances it is a profitable proposition to sell everything possible off the farm and purchase town refuse

as manure, reducing yard-feeding to a minimum. The rainfall is fairly abundant. The soils are loams, sometimes of the heavy and sometimes of the light type. The following rotation is designed for use on the better class of land under such conditions:

1st course	Potatoes.
2nd course	Wheat.
3rd course	Barley.
4th course	Seeds (first year).
5th course	Seeds (second year).

On the poorer classes of land seeds are usually taken in the third and fourth course and oats or barley in the fifth course.

A heavy dressing of town refuse is given to the potatoes and it is often supplemented with artificials. When sufficient town refuse is available the seeds ley also receives a light dressing of this manure. Two crops of hay are often taken, one in the first and one in the second year, the aftermath being grazed.

Potatoes, wheat, barley, and oats are sold, and sometimes also a portion of the hay and straw. The stock is kept principally on the pastures and housed as little as possible, so that very little farmyard manure is produced.

The five-course rotations differ considerably in character, and rotations of this class are practised on nearly all types of soil. Most of them include only one cleaning crop in the five years, and unless the land is carefully farmed it is liable to get foul before the end of the rotation. This class includes several rotations designed with a view to economy in labour, saving being effected by including a two-years ley. Broadly speaking the five-course system is practised very much more in the north and west than in the south and south-eastern parts of the country.

One of the chief drawbacks is the fact that the interval between two successive turnip and swede crops is short enough to enable finger-and-toe to live in the ground from one crop to the next. Thus in districts where this disease is troublesome a five-course rotation must often be modified. This is sometimes done by planting half the root area with potatoes, and in this way getting an interval of ten years between two successive turnip and swede crops, and sometimes by leaving the seeds ley down for three or more years and thus making a longer rotation.

Six-course Rotations

A rotation is practised in the north and north-west of England, in the south of Scotland, and in parts of the north of Scotland, which is simply an extension of the Berwick five-course obtained by leaving the seeds down three years instead of two; we thus get:

1st course	.. ..	Roots
2nd course	.. ..	Oats or barley.
3rd course	.. ..	Seeds (1st year).
4th course	.. ..	Seeds (2nd year).
5th course	.. ..	Seeds (3rd year).
6th course	.. ..	Oats.

TABLE III

Showing Cropping of Farm under Six-course Rotation for Years 1919–24

Section.	*1919.*	*1920*	*1921.*	*1922.*	*1923.*	*1924.*
1	Roots.	Barley or oats.	Seeds (1st year).	Seeds 2nd year).	Seeds (3rd year).	Oats.
2	Barley or oats.	Seeds (1st year).	Seeds (2nd year).	Seeds (3rd year).	Oats.	Roots.
3	Seeds (1st year).	Seeds (2nd year).	Seeds (3rd year).	Oats.	Roots.	Barley or oats.
4	Seeds (2nd year).	Seeds (3rd year).	Oats.	Roots.	Barley or oats.	Seeds (1st year).
5	Seeds (3rd year).	Oats.	Roots.	Barley or oats.	Seeds (1st year).	Seeds (2nd year).
6	Oats.	Roots.	Barley or oats.	Seeds (1st year).	Seeds (2nd year.)	Seeds (3rd year.)

This rotation resembles the Berwick five-course, but can be worked with a very small amount of labour as half the land each year is under grass, whilst only one-third is under corn and one-sixth under roots.

This rotation is followed upon the clay loam at Cockle Park,[1] where the following system of manuring has given very satisfactory results. 15 tons of farmyard manure are applied to the roots. Barley is grown in the second course and receives no manure. 10 cwt. of slag per acre (= 200 lb. phosphoric acid) are applied to the barley stubble for the seeds. Oats are generally grown in the sixth course and receive no manure.

On the loams of the Lothians, Fifeshire, Forfarshire, and other regions where potatoes are a successful and profitable crop, the Berwick five-course is modified by the inclusion of this crop. This variation is not

[1] *Guide to Experiments for 1921*, p. 78.

so economical of labour as is the above, but the potato crop more than pays for the extra expense entailed by its cultivation, whilst there is the additional advantage of getting two cleaning crops into the rotation. The sequence in this case is:

1st course	..	..	Roots (usually swedes and turnips).
2nd course	..	..	Barley or oats.
3rd course	..	..	Seeds (1st year).
4th course	..	..	Seeds (2nd year).
5th course	..	..	Potatoes.
6th course	..	..	Wheat or oats.

Farmyard manure is applied to both roots and potatoes, and, in both cases, is usually supplemented by artificials. Two crops of hay are often obtained from the seeds, and they also provide useful grazing.

Under this rotation the land is easily kept clean and its fertility is maintained at a high level, as not only does it receive two dressings of farmyard manure in six years, but for a portion of two years stock are grazed on it, whilst a considerable amount of organic material is added to the land by the decay of the roots and stubble of the leys when ploughed up.

One-half of the land produces marketable crops—potatoes, barley, wheat, and oats being available for sale—whilst sufficient roots, hay, and straw are produced to enable a considerable number of practically any kind of stock to be kept.

On some of the loams of the Midlands, where potatoes are not grown but corn is the principal product, a six-course rotation is followed which is completed by two corn crops, the sequence being:

			On Land in Poor Heart.		On Land in Good Heart.
1st course	..	..	Roots.	....	Roots.
2nd course	..	..	Barley.	....	Oats.
3rd course	..	..	Seeds.	....	Seeds.
4th course	..	..	Seeds.	....	Seeds.
5th course	..	..	Oats.	....	Wheat.
6th course	..	..	Wheat.	....	Barley.

The root area usually includes a breadth of mangolds and often cabbages, as dairying is largely practised in this neighbourhood. The roots usually receive a dressing of both farmyard manure and artificials. A light dressing of farmyard manure is sometimes given to the seeds in the autumn of the first year.

If a good plant of seeds is obtained the grasses effectively smother weeds, and the ground is left clean for the last two corn crops, but if only a poor plant is obtained the ground will be very foul by the sixth year.

One of the most important of the six-course rotations is the East Lothian. It is practised in the part of Scotland from which it takes its name and also farther north. The climate of this district is fairly moist; the soils are medium to light, and, as a rule, are well farmed and maintained in a high state of fertility. The sequence followed is:

1st course	Swedes and turnips.
2nd course	Wheat or barley.
3rd course	Clover or seeds.
4th course	Oats.
5th course	Potatoes or beans.
6th course	Wheat or oats.

In the first course the root crop consists entirely of swedes and turnips, which receive a light dressing of farmyard manure, often supplemented by artificials. The greater portion of the farmyard manure is given to the potato crop, which also usually receives artificials, and it is customary to top-dress the seeds with a nitrogenous manure, thus encouraging the grasses at the expense of the clovers. The beans receive a light dressing of farmyard manure.

It will be observed that this rotation embodies the six basic principles enunciated on p. 9. The selection of crops is such that the work on the arable land is distributed over the whole year, two cleaning and renovating crops are included in each period of six years, crops of varying habit of growth are grown, and a suitable interval elapses between crops of the same kind.

Of the crops grown, wheat, barley, oats, beans, and potatoes are all saleable, and the seeds hay can also be readily disposed of if it can be spared. The turnips are partly consumed by sheep and partly fed to beasts in the yards; fat sheep and cattle are mainly produced, breeding and rearing being carried on only to a limited extent.

On some fields which are particularly suited to potato growing the following sequence is followed:

1st course ..	Swedes.	4th course ..	Oats.
2nd course ..	Barley.	5th course ..	Seeds.
3rd course ..	Potatoes.	6th course ..	Potatoes.

On the heaviest type of clay, such as the Kimmeridge, Weald, and Oxford clays, wheat and beans are the most important crops, and six- and eight-course rotations are very popular. A rotation extensively used on the Oxford clay in Bedfordshire and Buckinghamshire is as follows:

1st course ..	Roots.	4th course ..	Wheat.
2nd course ..	Oats.	5th course ..	Clover.
3rd course ..	Beans.	6th course ..	Wheat.

The root crop consists mainly of swedes and mangolds, but an area of

cabbage is occasionally grown; Red Clover is often grown alone, but sometimes a mixture of clover and grass seeds is used.

The root crop receives a liberal dressing of farmyard manure, which is often supplemented by artificials; the land under preparation for beans also as a rule receives a light dressing of farmyard manure.

Beans can be hoed and thus kept clean until comparatively late in the summer, and as they enrich the soil in nitrogen may be regarded as a cleaning and renovating crop. This rotation therefore includes two cleaning and renovating crops in a course of six years.

Only one-sixth of the land is under roots, two-thirds being under corn. Heavy land farms usually include a considerable area of pasture, and this rotation is generally practised in conjunction with stock-rearing and dairying, the roots and part of the oats and beans being consumed on the farm. Two cuts of clover are usually obtained; the second cut is sometimes allowed to ripen and threshed for seed. The clover hay is usually sold on farms close to a market or railway, or it may be consumed at home; in the latter case the marketable produce is of small bulk, consisting principally of wheat. This rotation is therefore suitable for use on outlying farms.

There is a variety of six-course rotations designed to meet varying conditions, and rotations of this length are practised in most parts of the country and on nearly all types of soil. They may be conveniently divided into two classes: (1) those in which seeds mixtures are left down two and more years, and (2) those which include only one-year leys. The first class are economical in labour and are favoured for this reason, whilst the second owe their popularity to the comparatively large variety of crops included in the rotation.

Seven-course Rotations

Most of the seven-course rotations are extensions of six-course rotations, the two most common methods of effecting the extension being: (1) to leave the seeds down an extra year, (2) to grow an extra crop of either corn or potatoes. The rise in the rate of wages and the scarcity of labour has caused extensions of the former type in the west and north.

In the potato-growing region of the Lothians the following seven-course rotation is practised on some farms:

1st course	Swedes and turnips.
2nd course	Barley or oats.
3rd course	Seeds (1st year).
4th course	Seeds (2nd year).
5th course	Oats or potatoes.
6th course	Potatoes or beans.
7th course	Oats or wheat.

Potatoes are the most valuable crop in the rotation, as, in addition to the value of the ware, seed potatoes usually command a high price for export to England. The alternative crop, oats in the fifth course, and beans in the sixth course, are grown when the condition of the soil, or shortage of farmyard manure, or of labour, make it undesirable for potatoes to be grown. The rotation is fairly economical in labour, and also has the advantage of producing a fair amount of fodder, a very important point in years such as those prior to the war when stock was more profitable than corn.

A modification of the above rotation, which considerably reduces the amount of labour required to work the arable land, and also increases the stock-carrying capacity of the farm, is effected by leaving the seeds down for three years and omitting a corn crop, thus making the sequence:

1st course	Roots.
2nd course	Barley or oats.
3rd course	Seeds (1st year).
4th course	Seeds (2nd year).
5th course	Seeds (3rd year).
6th course	Potatoes or oats.
7th course	Potatoes or oats.

As previously pointed out, potatoes are the most profitable crop of these rotations, both the ware and seed potatoes being sold; there is only a small amount of corn produced, which can be either sold or consumed at home, and sometimes the seeds hay is sold. As regards stock, both cattle and sheep are fattened off, stores being purchased as required; very little stock-breeding is done.

The six-course rotation in use upon heavy land in some of the southern counties (referred to on p. 24) is frequently extended by leaving the seeds down for two years, the resulting sequence being:

1st course	Fallow crops.
2nd course	Oats or wheat.
3rd course	Seeds (1st year).
4th course	Seeds (2nd year).
5th course	Wheat.
6th course	Beans.
7th course	Wheat.

The seeds in the third course are usually cut twice for hay and a light dressing of dung given to the ley in the autumn; in their second year they are usually cut once for hay, the aftermath being closely grazed. The ley by the end of the second season usually contains a large number of weeds, and is therefore broken up in time to permit the necessary cleaning to be done before the succeeding wheat crop is drilled. In other respects this rotation resembles the six-course from which it is derived,

and the remarks made regarding that rotation on p. 25 may be also applied to it.

As an example of a seven-course rotation suitable for use on light land, we may take a rotation practised on some of the lighter soils in Wiltshire, which is as follows:

1st course	Roots.
2nd course	Barley.
3rd course	Peas.
4th course	Oats or wheat.
5th course	Seeds (1st year).
6th course	Seeds (2nd year).
7th course	Wheat.

The root crop consists principally of turnips and swedes, which receive the greater portion of the farmyard manure, and they are usually folded off on the land by sheep. A light dressing of farmyard manure is also usually given to the seeds in the autumn of their first year. Wheat does not do well on this type of land and is not so extensively grown as barley and oats.

Under this rotation careful tillage is necessary or the land will get foul, as only one cleaning crop is included in seven years. The peas, however, are usually harvested early, and a short bastard fallow may be taken late in the summer, after they have been removed. Thus, although weeds accumulate under this crop, the land can be cleaned before the succeeding corn crop is drilled. A certain amount of cleaning can also be done at the end of the sixth course if the ley be broken up sufficiently early.

Farms upon which this rotation is worked usually include a fairly large area of pasture, which is often only of poor quality, and on them sheep-breeding is a prominent feature, the flocks not only being folded on the roots but also run over the stubbles after the corn and hay have been removed.

In the Carse of Gowrie, a stiff alluvial tract in Perthshire, a seven-course rotation is followed which is worthy of notice. The sequence followed is:

1st course	Fallow or fallow crops.
2nd course	Wheat.
3rd course	Barley.
4th course	Seeds.
5th course	Oats.
6th course	Beans.
7th course	Wheat.

The fallow area is usually partly bare fallow and partly cropped,

swedes being the principal roots grown; potatoes are often substituted for part of the fallow. The greater part of the farmyard manure is applied to the fallow and fallow crops, but a light dressing of this manure is sometimes applied to the land under preparation for beans.

It will be noticed that a considerable variety of crops is grown, and also a very large proportion of their produce is saleable.

With regard to stock very little is bred, and beasts are fattened in the yards, while sheep are turned on to the aftermaths.

Eight-course Rotations

There are a number of eight-course rotations which are simply extensions of seven-course rotations, the extension being made by leaving the seeds ley down an extra year, and upon these we need not dwell. An extension of the Berwick five-course which is sometimes practised on heavier types of loam may, however, be examined. The sequence is:

1st course	..	Roots.	5th course	..	Oats.
2nd course	..	Barley.	6th course	..	Wheat.
3rd course	..	Seeds (1st year).	7th course	..	Beans.
4th course	..	Seeds (2nd year).	8th course	..	Wheat.

As in the case of the other Scottish rotations, turnips and swedes are the principal roots grown and receive a liberal dressing of farmyard manure, and often artificials in addition, dung occasionally being supplied also to the seeds in the autumn of their first year and for the beans. The wheat in the sixth course is usually top-dressed with a nitrogenous manure, and sometimes on land in poor heart receives a " complete " dressing of artificials.

Five-eighths of the land being under corn, this rotation is popular when the price of corn is high. Although two cleaning crops are included in eight years, these are close together, and land under this rotation will become foul unless farmed with care.

Grain being the principal saleable product, this rotation is suitable for use on outlying farms, especially in view of the fact that part or all of the oats and beans may be consumed at home. Sheep are not a prominent feature of the stock of farms on which this rotation is practised, the roots being drawn off the land and fed in the yard. Either fattening, breeding, or rearing may be conveniently carried on in conjunction with this rotation.

On the very heavy clays of Bedfordshire and Buckinghamshire, an eight-course is popular which includes two fallow breaks, the sequence being:

1st course	..	Bare fallow.	5th course	..	Roots.
2nd course	..	Wheat.	6th course	..	Oats or barley.
3rd course	..	Beans.	7th course	..	Clover.
4th course	..	Wheat.	8th course	..	Wheat.

Mangolds and swedes are the roots principally grown; an area of cabbages is, however, often included on dairy farms. A considerable portion of farms on this type of land is usually under permanent pasture and, as the stock is generally yard-fed during the winter, a large amount of farmyard manure is available for use on the arable land. The root crop usually receives a liberal dressing of this manure, which is frequently supplemented by artificials. Farmyard manure is usually applied to the beans, and occasionally a light dressing is also applied at the end of the bare fallow for the wheat which follows.

The most important feature of this rotation is the bare fallow, which is of great value on very heavy clays. Under it the land can be effectively cleaned, and the mechanical condition of the soil, which is apt to deteriorate considerably, can be restored. Bare fallowing is, however, a very wasteful practice, and it is a good policy, where possible, to take a quickly growing green crop at some time during the year. Vetches form the most popular crop for this purpose, and possibly the best time to drill them is the spring—after the land has had the benefit of the winter frosts; if drilled early, they may be cleared by the end of July, and the land can be ploughed up and cultivated during August. This is usually a dry month, and the weeds in the soil are, as a rule, killed by the dry weather.

Wheat, beans, and clover are the most suitable crops for very heavy land, and under this rotation five-eighths of the arable land is devoted to them. One-quarter of the arable land being under white crops, a considerable amount of straw is available for use in the yards during the winter, in spite of the fact that only part of the land of the farm is, as a rule, under the plough. Dairying and stock-rearing are generally practised on the farms where this rotation is in vogue.

On some of the loamy soils of the Lothians, an eight-course rotation is practised which is designed with the object of getting a fairly large area of potatoes, one-quarter of the arable land being devoted to this crop. The sequence followed is:

1st course	..	Roots.	5th course	..	Seeds.
2nd course	..	Oats.	6th course	..	Oats.
3rd course	..	Potatoes.	7th course	..	Potatoes.
4th course	..	Wheat.	8th course	..	Wheat.

The roots, turnips and swedes, are normally drawn off the land and fed to the stock in the yards, a fair amount of farmyard manure being

produced which is divided between the roots and potatoes; these crops also frequently receive a liberal dressing of artificials.

It will be observed that this rotation is very well balanced, and includes three cleaning and renovating crops in eight years, and the liberal supplies of manure applied for these crops keep the land in a high state of fertility. In spite of the fact that seven-eighths of the land is under cultivation each year, this rotation is fairly economical in labour on account of the work being distributed fairly evenly over the whole year.

Potatoes are the most valuable crop, owing to the value of seed potatoes in this district. The wheat can also be sold, and oats, if they can be spared, are usually readily sold to the manufacturers of oatmeal.

With regard to the stocking of the farms, breeding is but little practised, and only a few sheep are kept as a rule. The roots and fodder are principally consumed by fattening beasts in the yard.

On the light chalky soils of Hampshire and Wiltshire where the rainfall is fairly abundant, the Wiltshire eight-course is much in use. This rotation is designed with the object of producing as much feeding for sheep as possible, the sequence being:

1st course ..	Catch crop followed by roots.	5th course ..	Catch crop followed by roots.
2nd course ..	Barley.	6th course ..	Early turnips.
3rd course ..	Clover.	7th course ..	Wheat.
4th course ..	Wheat.	8th course ..	Barley.

The catch crops grown in the first course are vetches, trifolium, winter barley, rye, &c. They are drilled, so that a succession of keep is provided in the following spring. They are folded off and the roots which follow receive a liberal dressing of artificials. The roots are folded off and the land prepared for the second course—barley.

The catch crops in the fifth course are arranged to be ready for use when those in the first course are finished; they are folded off, and followed by late turnips, which stand the winter and come in for use in the early spring. They again are folded, and followed by early sown turnips. These are ready for use in the late summer and are then folded, and the ground prepared for the following wheat crop. Artificial manures are often used fairly liberally with both turnips and catch crops, the object being to secure as big a yield as possible. Practically no farmyard manure is produced on these farms.

The objects of this rotation are two—first, to enable large flocks of sheep to be kept on farms which are nearly entirely arable, and, secondly, to grow good crops of wheat and barley of high quality upon land which is naturally poor. The barley in the second course is grown on land

which has been twice folded in the preceding year. The wheat in the fourth course comes after clover upon which sheep have been grazed after the second cut has been secured. The land is not only rich in nitrogen added by the clover roots but also contains a considerable amount of organic matter owing to the large number of decaying roots of clover, and the manure added by the sheep. During the fifth and sixth courses the land is folded three times, and the seventh course finds the land as a general rule too rich to grow a good sample of barley, but it will produce an excellent wheat crop. This crop reduces the amount of available nitrogen in the soil, and an excellent sample of barley can usually be obtained in the eighth course.

As a general rule, on farms where this rotation is practised, very little stock other than sheep is kept and the principal saleable products are mutton, wheat, and good malting barley.

Eight-course rotations are popular on most classes of soil, and this class includes rotations designed for use under widely varying conditions. The most noticeable feature of these rotations, as a rule, is the large number of different crops grown. With one or two exceptions, the area under root crops is small, whilst that under grain crops is comparatively large.

Rotations containing more than Eight Courses

Rotations containing nine, ten, and even more courses are sometimes practised, but are not at all common. They are usually merely extensions of one of the systems we have discussed in the previous chapters, formed either by leaving the seeds down for several years, or by substituting sainfoin or lucerne for this crop.

As an example of this type we may take a rotation sometimes practised upon light calcareous soils, the sequence being:

1st course	Turnips.	5th course	Turnips.
2nd course	Barley.	6th course	Barley.
3rd course	Clover or peas.	7th course	Sainfoin (common).
4th course	Wheat.	8th course, &c.	Sainfoin (common).

It will be observed that this is only an extension of the Norfolk four-course. Where this rotation is followed, it is not usual to plant an area of sainfoin each year; the land is generally worked in five sections, one of which is under sainfoin, the remainder being farmed on the four-course system. When the sainfoin shows signs of failing, an area is drilled on another section and the old ley ploughed up. The life of sainfoin being somewhat variable, the sainfoin is moved to fresh ground at very irregular intervals. These remarks also apply to rotations where

lucerne is included, and also to rotations practised in parts of Scotland which include a long ley of timothy.

On some of the clay lands, in dairying districts of Ayrshire, which are unsuitable for the production of roots the following rotation is practised:

1st course	Oats or mashlam.[1]
2nd course	Mashlam or oats.
3rd course	Ryegrass cut for seed and subsequently grazed for three, four, or more years.

The practice of harvesting the Ryegrass for seed in the first year may be noted. At one time Ryegrass seed was a very profitable crop, but it certainly decreases the value of the ley in after years, and as this is left down for several years it seems questionable whether at the present time the value of the Ryegrass seed compensates for the deterioration its production causes. It will also be noticed that this rotation contains no root crop; the reason for this seems to be that on the farms where this rotation is practised, in the past the milk has been produced for cheese-making either on the farm or at a local factory. Cheese is chiefly made in the summer months. When milk is produced for this purpose, all the cows are calved down in the spring and are dry during the winter, with the result that roots and other succulent fodder can be dispensed with if plenty of good hay is available.

Cross Cropping and Flexibility of Rotations

The point has already been emphasized that a rotation should not be looked upon as a rigid system which cannot be altered, but rather as a flexible framework which can and should be adapted to varying requirements. Crops of a similar type can be interchanged without altering the general idea of the sequence, but it frequently happens that it is desirable to grow a crop not normally included in the rotation or to extend the area of one which is normally included. This may necessitate the displacement of one of the regular crops by one of a different type. Such a substitution is commonly termed cross cropping.

Cross cropping was at one time looked upon as a bad practice. If due care is not exercised it may easily result in the land getting into poor heart, bad condition, or becoming foul, but if due consideration is given to manuring and cultivation even drastic temporary changes may be made with satisfactory financial results. The following is an example of cross cropping in the Norfolk four-course rotation, of a type which was quite common during the war when wheat was badly required in

[1] A mixture of oats and beans.

his country. It shows some of the difficulties which may have to be met when drastic substitutions are made in a rotation.

Section.	1914.	1915.	1916.	1917.	1918.	1919.
1	Roots.	Barley.	Wheat.	Wheat.	Roots.	Barley.
2	Barley.	Clover.	Wheat.	Roots.	Barley.	Clover.
3	Clover.	Wheat.	Roots.	Barley.	Wheat.	Wheat.
4	Wheat.	Roots.	Barley.	Wheat.	Wheat.	Roots.

In this case in the years 1916, 1917, and 1918 no clover was grown, the section which should have been clover being cropped with wheat, with the result that on sections 1, 3, and 4 three white-straw crops were grown in succession. In a case of this description not only would the land get into poor heart and condition but very inferior crops of wheat would be obtained unless special manuring were given, as not only were three white-straw crops taken in succession, but the soil loses the nitrogen normally added by the clover crop. A satisfactory yield would probably be obtained from the first of the two wheat crops by giving this crop a fairly liberal top-dressing of a nitrogenous manure, but the second wheat crop would need a complete manure to enable it to maintain its yield. For this purpose farmyard manure would be better than a mixture of artificials, as it has a beneficial effect upon the "condition" of the soil, which always deteriorates under continuous cereal cropping. A still better scheme of manuring would be to apply the farmyard manure to the first of the two wheat crops and give the second a light dressing of superphosphate and a nitrogenous manure.

As more straw is produced under the modified rotation than in the normal course, more farmyard manure can be made, and the dressing of this manure required by the wheat need not necessarily reduce the amount available for the root crop, but if it does, it would be well to increase the amount of artificials applied to the latter crop, otherwise the yield would suffer.

When only one rotation is followed upon the farm the arrangement of the scheme of cropping is comparatively simple. A certain amount of care may be necessary in dividing the land up into the required number of sections, especially where the land is in small fields which it is not desirable to subdivide, and a certain amount of manipulation may be necessary during the first few years, but when every section has once been got under its proper sequence very little further trouble is necessary. It not infrequently happens, however, that there is more than one type

of soil on a farm, and two or more rotations are employed. In such cases the scheme of cropping needs careful consideration each year, or the area under fallow and fallow crops may be excessively large in some years, for although the area under grain or seeds may sometimes be increased without any detrimental effect upon the economical management of the farm, if the area under fallows be unduly inflated very serious inconvenience may easily be caused. Bare fallow brings in no return at all for the year, and if an excessive amount of roots is grown they frequently cannot be disposed of. Bare fallows and fallow crops need a comparatively large amount of cultivation, and even when the farmer's financial position enables him to stand the expense of an extra large area under fallow cultivations in one year, the necessary labour is frequently not to be obtained to enable these cultivations to be carried out efficiently.

We will now study an actual instance of the cropping of a farm for a period of eight years. In the previous pages we have only studied the working of rotations under typical couditions. This example will serve to illustrate the working of two rotations upon the same farm, and at the same time illustrate the way rotations work out in actual practice.

Table IV is an extract from the crop record of a farm which was worked partly on the Bedfordshire eight-course and partly on the Norfolk four-course rotations.

The farm consisted of 340 ac. of land, 111 of which were arable. A herd of dairy cows was kept and a flock of breeding ewes, and a small flock of tegs were fattened off on the surplus turnips each autumn, the remainder of the tegs being sold as stores.

The soil of Milton Field, Upper and Lower Doles, and Home Field was very heavy clay, and was farmed on the eight-course system. That of Lambs Field, Upper and Lower Moors, and Washingbrook varied from light loam to a sandy soil, and on these fields the Norfolk four-course was used.

There are several points in the extract from the crop record given in Table IV which are worthy of notice. In the first place, although the heavy land was worked upon the eight-course system, it was only divided into four sections, three courses of the rotation being omitted each year. This land was divided up into four fields, and to have obtained eight sections each field would have had to be split into two sections, whereas under the arrangement followed the only fields which were divided up were the ones under fallow each year, and the one under the corn crop which followed the fallow year.

Each year the area under fallow was divided into two parts, one of which was devoted to roots and the other to bare fallow, the portion under roots during one fallow break being under bare fallow when the field was again fallowed. Bare fallow is normally followed by wheat, but on this class of land the mangolds, which are on the same section as

AGRICULTURAL COLLEGE AND ... INSTITUTE
No.
15 AUG 1927
COIMBATORE

Eight-course Rotations

Field.	Area.	1909. Crop.	Area.	1910. Crop.	Area.	1911. Crop.	Area.
Milton Field.	8 o	Oats .. Wheat ..	10 8	Clover ..	18	Wheat ..	18
Upper Doles.	8 4	Clover ..	12	Wheat ..	12	Mangolds .. Bare fallow ..	6 6
Lower Doles.	4	Wheat ..	14	Mangolds .. Bare fallow ..	7 7	Oats .. Wheat ..	7 7
Home Field.	6	Mangolds .. Bare fallow ..	8 8	Wheat ..	16	Beans ..	16
Lambs Field.	6 2 4	Barley ..	12	Peas	12	Wheat ..	12
Upper Moors.	4	Peas	14	Wheat ..	14	Swedes .. Cabbage ..	8 6
Lower Moors.	o	Wheat ..	10	Swedes .. Cabbage ..	6 4	Barley ..	10
Washingbrook.	5	Swedes .. Cabbage .. Turnips ..	6 4 5	Barley ..	15	Clover ..	15

TOTAL AREAS:	1909.	1910.	1911.
Wheat	32	42	37
Barley	12	15	10
Oats	10	—	7
Bare fallow ..	8	7	6
Cabbage	4	4	6
Mangold ..	8	7	6
Swedes	6	6	8
Turnips	5	—	—
Peas	14	12	—
Beans	—	—	16
Clover	12	18	15
Total	111	111	111

bare fallow, are not as a rule got off the land sufficiently early to permit wheat to be put in under favourable conditions, and spring oats usually follow the mangold crop. Hence the necessity for dividing the corn crop which follows the fallow year.

In planting the root area the requirements of the dairy herd, young horned stock, and ewes and lambs were first considered, as nearly as possible 8 ac. of mangolds, 4 of cabbage, and 3 of swedes being planted for this purpose. The remainder of the root area was devoted to swedes and turnips, which were folded off. The roots required for the dairy stock and the ewes and lambs were drawn off the land, and as far as possible those produced on the heavy land were utilized for this purpose. In 1904, 1905, 1908, and 1909 there was no difficulty with the root area, but in 1906 the area under fallows was comparatively small, only 24 ac. being available, of which only 7 ac. should normally have been mangolds. In the spring of 1906 there was only a small supply of old hay in the rick-yard. It was therefore decided to put in an extra area of mangolds, i.e. 8 ac. instead of 7 ac., and to reduce the area under bare fallow to 6 ac. In the years 1907 and 1911 only 6 ac. of mangolds were provided for under the rotation, but it was possible to grow 2 ac. extra of both swedes and cabbages to compensate for the shortage in mangolds. In 1910 there was again only a comparatively small area, 24 ac., under fallows, of which 7 ac. only should come in for mangolds, but as in this year there was a surplus of old hay in the rick-yard this area was considered sufficient.

Owing to the fact that three courses were omitted from the eight-course rotation each year, in some years clover was produced on the heavy land and in others it was not. The same thing happened with beans. On referring to Table IV it will be seen that in the years 1907, 1908, 1909, 1910 clover was grown on the heavy land but no beans were produced; on the other hand, in the years 1904, 1905, 1906, and 1911 no clover was produced but beans were grown.

It was not desirable to have too great an area under clover, therefore in the years 1907, 1908, 1909, and 1910, in which this crop was grown upon the heavy land, it was not grown on the light, its place in the rotation being taken by peas. On the other hand, in the years 1904, 1905, 1906, and 1911, in which no clover was produced on the heavy land, it will be seen on referring to Table IV that this crop was grown on the light land, peas not being grown. If we tabulate the leguminous crops this point will be made clear.

	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Heavy land ..	Beans.	Beans.	Beans.	Clover.	Clover.	Clover.	Clover.	Beans.
Light land ..	Clover.	Clover.	Clover.	Peas.	Peas.	Peas.	Peas.	Clover.

It will be seen that this adjustment has two results: (1) clover was produced either on the heavy land or the light but never on both in the same year, thus the area under this crop varies only slightly year by year; (2) one of the leguminous pulse crops was grown each year, but never both.

A reference to Table IV will show that in every case successive clover crops on the same land are separated by an interval of eight years.

It will be noticed that although the areas under wheat, barley, and oats vary considerably from year to year, the total area under white-straw crops each year does not vary to any great extent, and also that only a small area is under bare fallow each year. The total area under the four fallow crops does not fluctuate to an inconvenient extent.

ENSILAGE

BY A. W. OLDERSHAW, M.B.E., B.Sc.

Ensilage is the process whereby crops are preserved in a green state. It has been known for a very long time that crops can be preserved in this way, but it is only in the past century that the practice has become common. Even so long ago as the time of the builders of the pyramids the practice was not unknown, whilst we are told that Julius Cæsar made silage in pits lined with clay to provide food for his horses when required.

Much interest was taken in ensilage about the end of the nineteenth century by many of our prominent agriculturists. There were at that time in Great Britain more than a thousand silos of various types—brick, concrete, slate, and wood being used as building materials. Most of these buildings were of more or less rectangular shape, in this respect differing from our modern silos, which are mostly cylindrical. Silage was also made in stacks above ground and in pits of earth.

Clover, trifolium, and meadow grass were regarded as excellent for silage, but other materials such as lucerne, vetches, green oats, barley, wheat, peas, and beans were all made into silage with more or less success. It seems to have been the general opinion at that time that the cost of making silage was less than that of making hay, especially when wet weather prevailed. The silage made by the method then in vogue appears to have been perfectly suitable food for stock, especially dairy cows. Usually from 25 to 50 lb. of silage were fed daily to cattle with other foods.

A number of experiments were conducted on various points of interest connected with ensilage by the National Agricultural Societies, and by many private persons. A report on experiments conducted at Portmore, by Mr. J. Mackenzie, appears in the *Transactions of the Highland and Agricultural Society of Scotland* for 1885. Mr. Mackenzie concluded that most forage crops can be made into silage, which material forms a suitable food for all classes of stock. He also considered that grass crops can be conserved at a somewhat less cost by making silage than by making

into hay, and that the system of ensilage has the further advantage that it is independent of the weather. It is true that when making silage one is much less dependent upon the weather than when making hay, and even heavy showers do not matter very much; but, on the whole, it is a mistake to make silage in pouring rain. The amount of useless water carted home is very large, and the silage made is sour and somewhat unpleasant to handle owing to its smell. A considerable volume of liquid also drains out of the silo when very wet material is put in. Still, the silage may be of fair quality even when made in wet weather.

Mr. Mackenzie also pointed out that, in late districts and seasons, certain crops such as aftermath, cereals which fail to ripen, &c., are frequently damaged and sometimes lost. These could, in most cases, be made into silage. He also concluded that cattle and sheep thrive as well upon silage as upon turnips, and that under this system it is possible to work with less cultivation and consequently with less expense.

In the summer of 1885, experiments were conducted by the " Bath, West and Southern Counties Society ". These experiments showed that there was a considerable loss of nutritive material, expecially of non-nitrogenous substances, in converting grass into silage, and that the albuminoid constituents were more reduced when sour than when sweet silage was made. After about 1890, interest in the practice of ensilage in this country gradually died out, although why that should have been so is not easy to understand.

In America, ensilage has been taken up with great enthusiasm, and lately a very large number of silos have been built.

Recently there has been a revival of interest in Great Britain and Ireland, largely owing to the introduction of the modern cylindrical silo which has proved so successful in America.

It is probable that the great success of ensilage in America is partly due to the cylindrical silo and partly to the great bulk of fodder per acre produced by maize, the chief American silage plant.

The practice of ensilage appears to have become more popular in East Anglia than many other parts of England. In that district alone, seventy to eighty cylindrical silos have been erected in the past few years, and more are in course of erection. Several firms of timber merchants have taken up the erection of wooden stave silos, whilst there have been quite a number of concrete silos erected.

Advantages of Making Silage.[1]

We may very well ask at this stage, what are the advantages of making silage?

There are quite a number of points in favour of the system. By this method a large bulk of food is produced at a low cost, the crop can be

[1] *Journal, Board of Agriculture*, March, 1916.

ensiled in June or July when the land is dry and the days are long, and there is no risk of early frost as with mangolds. But the claim made that there is almost a certainty of obtaining a crop, appears to be somewhat over-confident.

The oat and tare crop, which is specially suited for ensilage in this country, is possibly less likely to fail than roots, but in the years 1917 and 1919 poor crops were obtained—in 1917, probably owing to the severe frost in the winter killing or injuring the tares, and in 1919, to a very wet and cold winter, followed by a seven-weeks drought in May and June again causing a comparative failure of the tares on heavy land. It is also claimed by those who advocate silage that the land is cleared early, and, where suitable, is then made ready for turnips.

This is a perfectly sound proposition, and the writer has on several occasions weighed quite good crops of turnips grown after a silage crop, on easily worked soils. On heavier soils, mustard can be grown and ploughed in, or perhaps better, a bastard fallow can be made, provided the weather is suitable.

It is probably true that a saving of labour is effected in feeding silage as compared with feeding roots. The claim made that more stock can be kept under a system of ensilage than where roots are grown, and that consequently more dung will be available, seems somewhat doubtful; though it is more likely to be true where for any reason a good yield of roots cannot be obtained. Stress is laid, by silage advocates, upon the slag applied to the tares and to the nitrogen accumulated by that crop. The benefit derived by the application of slag to suitable soil cannot easily be over-estimated.

There can be no doubt that the tare crop produces a very large bulk of green fodder, and any method which will enable it to be cultivated in this country on a larger scale is an advantage. The very limited area of tares at present grown is no doubt due to the difficulty of making the crop into hay, especially in the wetter districts of Great Britain.

The making of silage can be carried out successfully in showery weather, although, as previously pointed out, it is on the whole better not to put materials which are soaking wet into the silo.

The point raised by some, that under the silage system it would be possible to plough up some of our poor grassland, and so permanently increase the home-grown food supply by increasing the area under tillage, seems to the writer to be very important.

It is well known to all agriculturists that there are considerable areas of poor land, heavy and light, which have been allowed to go down to inferior grass and are now producing very little food for the nation. Any agricultural method which would enable this land to be better utilized is deserving of most careful consideration. Under present conditions, we are confronted with grave difficulties in the cultivation of this class of land,

owing to the greatly increased cost of production. If ensilage helps in any way to stay this process of reversion to grass, it will perform a very useful service to the community. The vastly greater productivity of arable land, as compared with grassland, is now generally admitted. The observations of the writer lead him to think that on the same land a crop of tares will produce three or four times as great a weight of green stuff as will a crop of grass. This is especially the case on poor heavy land in a dry climate. On such land, when a dry, hot May follows a cold March or April, hardly enough grass may grow to be worth mowing. There can be no doubt that not only does arable land produce crops such as corn and potatoes, which can be directly consumed by human beings, but it also produces a far greater bulk of animal food.

Oats and tares, most generally used for ensilage in this country, are very useful as a smothering crop. Weeds such as Couch Grass and Coltsfoot are not actually killed, but they are considerably checked, and a subsequent bastard fallow may enable the farmer to obtain a clean seed-bed for his wheat.

In Great Britain, silage made from leguminous crops such as tares, sainfoin, lucerne, &c., has been found excellent feeding material. As is well known, these crops possess the extremely valuable property of assimilating the free nitrogen of the air, in this way enriching both the field in which they grow and subsequently the manure heaps, in that plant food which costs the farmer most to buy and in which most poor land is lacking. Ensilage enables the farmer to utilize to greater advantage the succulent leguminous crops mentioned, and an extended acreage of these is advantageous to agriculture.

It is also worthy of note that silage made from these crops, being richer in albuminoids than roots and straw, renders such animals as milking cows, which require a large supply of nitrogenous materials, less dependent upon concentrated foods such as cakes and meals.

After a careful examination of modern systems of ensilage as practised in East Anglia, and experience of the results obtained, the conclusion has been reached that the extension of the system would be an advantage in many districts of Great Britain.

Wherever root-growing is unsatisfactory, either owing to a dry climate or poor soil, the system possesses decided advantages. In wet districts also, where hay-making is difficult, it is of very great service to have a method of preserving fodder which is more or less independent of the weather. In most cases it will be found convenient to grow a somewhat smaller area of roots and to supplement the roots with an allowance of silage. Under modern conditions it is a very costly business to grow a large area of somewhat indifferent roots, and it will probably be found better to endeavour to grow a large crop on a small area and to make up with silage. On good land where crops of 30 to 40 tons of roots

can be obtained fairly regularly, it is unlikely that ensilage possesses great advantages except possibly where lucerne and sainfoin can be utilized as a silage crop, or where crops can be used for this purpose which would otherwise be damaged by the weather or wasted.

The amount of digestible dry food given by a 40-ton per acre crop of mangolds is very large—decidedly larger than can be expected from a silage crop. The labour on the roots, however, is greater. It is, as previously pointed out, where poor crops of roots are usually obtained that ensilage comes most into prominence.

Many farmers have now taken to making silage and the system is spreading. There are already a number of cylindrical silos in Scotland and many in various parts of England. As the methods adopted become better known it seems likely that ensilage will become very important to the British farmer in keeping his land in cultivation in the rather uncertain times which are ahead.

Methods of making Silage.

The methods adopted in making silage may be roughly divided into three groups:

1. By the use of a modern tower silo.
2. By the use of a building converted for this purpose.
3. By making without any building, and with only very simple apparatus.

Tower Silos.

We have in this country at the present time a great many cylindrical tower silos of the modern American pattern. They are usually of considerable height, from 20 to 40 ft., and from 12 to 20 ft. in diameter. They are built of concrete, brick, or wood.

Owing to their height no pressure is needed as was the case with most silos built in former times. The weight of overlying masses of silage provides what pressure is necessary.

The type at present in favour, and indeed that which gives the best results, is the tall cylindrical tower which can be likened to a wide chimney. This type has proved itself immensely superior to the square, shallow silos. Generally the proportion of height to diameter is, at least, $2\frac{1}{2}$ to 1.

Down one side of these towers there is a slot in which are fitted hatch doors, one above the other. This opening is covered by a chute to direct the fodder when thrown out.

Concrete Tower Silo.

Wood, concrete blocks, mass concrete, and reinforced concrete have all been used in the construction of tower silos, but of these materials

the most efficient and common in use is reinforced concrete. The concrete walls are best constructed on a monolithic principle; this means that the walls are one continuous mass from top to bottom, being built in rings each of which is added before the previous ring or course is set and therefore the walls are jointless. The concrete should be reinforced with mild steel bars.

The base consists of foundation and floor made of reinforced concrete, and forming a saucer draining towards the centre which is occupied by a grid over a fireclay pipe. This pipe leads to a concrete tank and through it drain the excess silage juices which can profitably be used in feeding pigs. (Feeding value approximately equal to whey.)

The walls are erected on this foundation and should be about 6 in. thick. A certain amount of care should be bestowed on the smooth finish of the inside. These walls should be made of the best quality of materials, in proportions of 4 of $\frac{3}{4}$-in. whinstone chippings or clean, small gravel, 2 of clean, sharp sand, and 1 of the best Portland cement. Inferior materials will cause a leaky wall.

The top of the silo should be covered in by means of a concrete roof, conical in shape. Through this roof there open two dormer windows, one of which is continued out over the top to the concrete chute and forms a means of ingress to the silo. Through the other window is led the filling pipe. Between these two windows a wooden platform is required in order that the filling pipe may be adjusted before commencing to fill the silo.

Down one side of the silo there is left a slot or series of openings into which are fitted, when the silo is being filled, a number of wooden doors or hatches. Over the surface of this slot is built a concrete chute which directs the silage when thrown out from above. A ladder is usually placed inside the chute to form a means of ascent.

The diameter of filling pipes varies with the different types of silage cutters, but no matter what diameter the pipe may be, an effort should be made to make the inside of the pipe as smooth and continuous as possible in order that it will offer little or no resistance to the passage of the crop on its way to the top of the silo. This pipe may be either removable, being placed in position only when required, or may be a permanent structure. If the latter of these it should be out from the wall about 12 in. in order to sit more or less vertically over the mouth of the silage cutter. As can readily be understood any joints or angles on such a pipe greatly reduce the speed of filling, as the pipe will choke when the machine is fed above a certain speed.

Since the silo is entirely of concrete, it is practically indestructible if soundly designed to meet the great pressure during the filling and settling of the silo. With the wall only 6 in. thick very careful workmanship is required to give practical watertightness, but even with the most careful

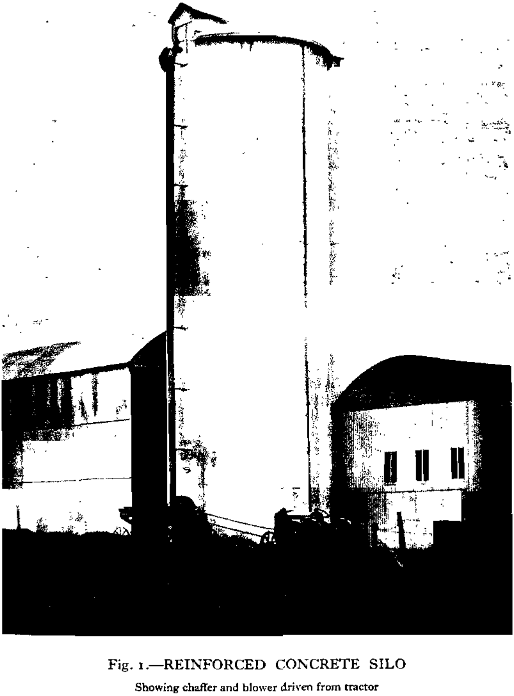


Fig. 1.—REINFORCED CONCRETE SILO

Showing chaffer and blower driven from tractor

Facing p. 42, Vol. IV

attention and the best materials such a wall will not be watertight if the silo is treated as a water-tank. In other words the crop requires to be in a wilted condition when fed into the silo if loss through excess moisture is to be avoided.

Brick Silos.

There are several brick silos in Hertfordshire, the commonest size being 30 ft. high and 15 to 20 ft. in diameter. Some of these, built before the war, cost less than £120.

One of these is built of 14-in. brick walls, reinforced with hoop iron, is 28 ft. high and 20 ft. in diameter, and cost £200.

The roof is covered with weather boarding and there is a Boyles ventilator on the top. The inside of the silo has a coating of cement, and it is polished perfectly smooth with a steel trowel.

It resembles the silos recommended by the Food Production Department in that the material is put in unchaffed.

Wooden Silos.

Quite a number of wooden-stave silos have been recently erected. This type of silo resembles a huge barrel, except that the sides are perpendicular instead of bulging. Iron bands are placed around the whole structure and hold the staves together, and an arrangement is made whereby the bands can be tightened up when required. A usual size is 16 ft. internal diameter and 32 ft. high. A foundation is made of concrete; wire cables attached to posts serve to anchor the silo in place and prevent its blowing over. Doors are arranged in the side of the silo, one above the other, from the ground to the roof to allow of the silage being removed. In many cases a wooden chute to guide the silage to the ground is attached. The workmen climb up the silo by means of bars across the doors.

It is only within recent years that silos of this type have been erected in this country, hence it is not possible to say how long a wooden structure of this nature will survive British climatic conditions. None of those erected, as far as the writer is aware, has as yet blown down, or shown very evident signs of decay. In this connection it is interesting to note that Colorado Agricultural College in *Bulletin* 200 states that the life of the stave silo varies from 5 to 20 years, according to the quality of the material used, the method of construction, and the care and attention given to the silo.

The Hoard Silo.

The Hoard silo is something new in silo construction, and designed on a different principle from that of the ordinary vertical-stave silo.

Because of the expansion and contraction that occurs according to weather conditions, timber has been at a distinct disadvantage compared

to concrete. This difficulty has been partly met in the case of the vertical-stave silos by encompassing them at frequent intervals by metal hoops, but it has been found that even with the very best care it is not always possible to keep the walls airtight.

In the Hoard silo the timbers are placed in a horizontal position, and eight of them form one course of an octagonal wall. Each piece is tongued and grooved and interlocks with the adjacent piece by a half-check joint cut at an angle of 45°. The courses are approximately 6 in. high, and they are built successively on top of one another on a concrete foundation until the desired height is obtained. There are no hoops, and the silo adjusts itself as regards expansion and contraction, all the parts remaining tight due to its own weight and the interlocking of the pieces. At regular intervals there are door spaces, the doors being fitted from the inside as the silo is being filled. When in position, the continuity of the inside wall is maintained. Both above and below the door spaces are bolted 3 in. by 4 in. pieces grooved to provide hand hold, and these serve as the ladder.

The chute is suspended by slip bolts, and the roof is piend shaped, there being an entrance for the filler pipe.

Anchors placed in alternate corners hold the roof in position and give extra stability to the silo. These anchors are wire cables running from the roof and attached to stretchers in the concrete wall.

From the description it may be seen that this type can be easily erected; it can be dismantled and re-erected elsewhere and additional height may be added if desired.

Size of Cylindrical Silo.

It is very important not to have a silo of this type too large for one's herd. It is found that unless about 2 in. thickness are removed daily from the top during the feeding season, waste occurs from moulding.

The following table, taken from a paper by Mr. J. H. Grisdale, Director of the Canadian Experimental Farms, gives the estimated weights of the contents of various sizes of silos:

Height in feet.	Inside Diameter in feet.				
	15.	16.	18.	20.	24.
	Tons.	Tons.	Tons.	Tons.	Tons.
20	58	66	84	104	150
24	76	86	109	135	194
30	105	119	151	186	268

Area of Crops required to Fill the Silo.—The Food Production Depart-

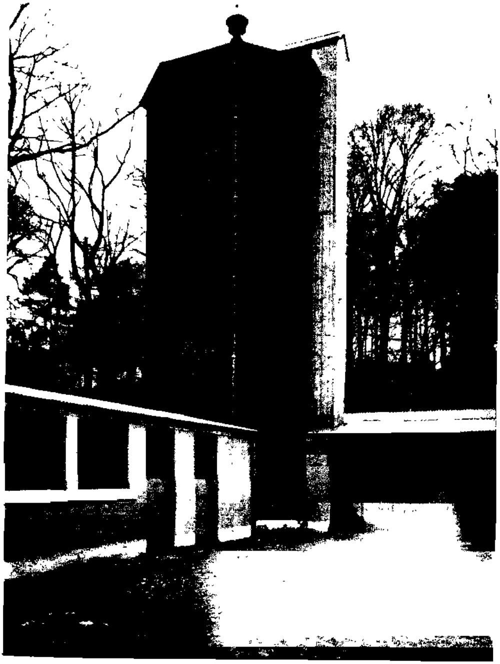


Fig. 2.—THE HOARD SILO

Facing p. 44, Vol. II

ment of the English Board of Agriculture gave the following table as indicating the area of crops required to fill a silo under British conditions.

Crop for Silage.	Acres of crop required to fill a silo 15 ft. diameter and 30 ft. high holding about 100 tons of silage and suitable for a herd of 25 cows.	Acres of crop required to fill a silo 12 ft. diameter and 24 ft. high holding about 50 tons of silage and suitable for a herd of 12 cows.
Maize	6	3
Oats and Vetches	9½	4¾
Lucerne (two cuts) ..	9½	4¾
Red Clover and Ryegrass ..	13	6½
Red Clover	15	7½
Meadow Grass	17	8½
Sainfoin	12	6

Site of Tower Silo.

It is important that silos of every kind be erected as near as possible to the place where the silage will be fed, in order to save labour in handling the material. In some cases in East Anglia the chute has been arranged to empty directly into the mixing house.

At Hawkesbury Agricultural College, New South Wales, there are four silos in a square which empty into troughs on rails and these go direct to the cattle. The same cutter and elevator, permanently placed, does for all four silos.

Cost of Tower Silos.

At pre-war prices wooden-stave, brick, and concrete silos seem to have all cost very much the same on an average; possibly for the same size the wooden silos were a little cheaper. The cost of concrete buildings naturally varies very much according to the proximity of suitable gravel and sand, and the extent to which old iron can be utilized for purposes of reinforcement.

Wooden, Brick, and Concrete Silos Compared.

Wooden silos possess the great advantage that they can be removed, and hence are more suited for erection by tenant farmers. The operation of moving is, however, somewhat costly.

There appears to be little doubt that concrete and brick silos, if care-

fully erected, will prove to be more durable than wooden ones. In America, where silos have been erected for a much longer time, and where there has consequently been a better opportunity to test their durability, it appears that the percentage of failures is less in concrete than in most other types. In East Anglia there appears to be no difference in the quality of the silage made in the various types of tower silos, provided similar materials are put into them.

Filling the Tower Silo.

Tower silos are usually filled by means of a combined chaffer and blower, which first chaffs the green material, then by means of a blast of air elevates it to the top of the silo.

Many East Anglian farmers use an American machine (the Ohio) for this purpose. The machine is driven by an ordinary traction engine. In one case an ordinary Maynard chaff cutter has been fitted with a blower and tube, at a cost of £25. This arrangement answers admirably, and the farmer claims that the Maynard cutter uses less power than the Ohio, which rather bruises the material than makes a direct cut.

Several farmers have devised endless-chain elevators, to which are attached cups or slates to carry the chaffed green material upwards. These are attached to chaff cutters already in possession and are worked by a tractor or oil-engine.

The tower silo recommended by the Food Production Department has a large opening at the top which permits the entrance of unchaffed green material. This saves the cost of chaffing and enables the ordinary farm elevator, which is already possessed by many large farmers, to be utilized for filling. The farm elevator may be driven by horse-power or by a small petrol-engine.

If lorries, low drays, or similar vehicles are available, they will be found somewhat more convenient for carting the green material than the ordinary farm-carts used in England.

When there is a heavy crop it will be a saving of labour not to collect the green material at all, but to have three or four people pitching direct on to the carts.

In a tower silo there is a certain amount of danger of suffocation to anyone entering two or three weeks after filling, owing to the presence of carbon dioxide. This danger may be obviated by leaving open the doors of the silo at the level of the silage. Owing to the access of air, a certain amount of waste occurs at the top of the silo. This may be largely prevented by putting a load of waste material, such as green vetches, &c., on the top. A layer of sand at the top is also very good for the purpose, but it is very heavy to haul to the top of the silo.

Essentials of a Successful Tower Silo.

There are certain fundamentals to be observed in building and designing a silo.

1. A silo should be tall and of small cross-sectional area, that is, the capacity should be obtained rather by height than by width.
2. It should be practically airtight and watertight. If the silo is not almost airtight a good deal of wastage goes on which ruins the economy of the system.
3. The interior walls should be smooth and perpendicular. If this condition is not enforced the silage does not sink uniformly; air pockets are formed in the mass and some of the food is spoiled.
4. It should be designed so that a minimum of labour is required to work it.
5. It should be stable and weatherproof, which condition is as a general rule in direct proportion to the price paid for the building.
6. It should stand on solid ground.
7. It should be of such a cost that the farmer with limited capital does not require to tie up money which he needs to conduct his business.

Making Silage in Old Barns, &c.

We have now considered the modern tower silo at some length, and it is desirable to discuss those cases where a building is already in existence which can be utilized as a silo.

Quite a number of old silos occur in various parts of the country, and frequently by a little modification they can be altered to suit modern requirements. In many cases rectangular silos exist, often partly below the ground. Such a silo, if from 10 to 15 ft. high, may be quite well utilized, but it is better to put some weight such as logs of wood upon the chaffed material when filled in.

Again, several cases have been noted in which silage has been made in the corner of a barn, the sides of which have been strengthened with concrete. Here, owing to the fact that there is not usually a great depth of silage, it has been found necessary to cover the material with boards and weights. In one case the end of a shed was divided off by means of closely fitting boards and filled with chaffed green maize. This, when weighted down by means of planks and old iron, made excellent silage.

It will thus be seen that it is quite possible to make good silage in buildings which were not originally intended as silos, but which have been slightly altered in order to fit them for the purpose.

Deep Pit Silos.

The only silo of this type seen by the writer in this country is in Suffolk. A cylindrical hole, 12 ft. deep and 18 ft. in diameter, was

excavated in the sandy soil. By fixing sheets of corrugated iron round the edge, a further 6 ft. of depth was obtained. The sides of the pit were then cemented. Chaffed green material was used to fill it, and good silage resulted, although there was a certain amount of waste on the sides.

The United States Department of Agriculture, *Bulletin* No. 825, entitled "Pit Silos", strongly recommends this type of silo where the soil is very dry and free from rocks, and there is no fear of underground water entering. There are undoubtedly many parts of Great Britain where these conditions obtain and where this type of silo might prove very cheap. A concrete curb around the edge of the pit is recommended. This should be made before the soil in the centre of the intended pit is excavated. A swinging crane, windlass pulleys, and rope are arranged on the edge of the pit to hoist the silage out. This should be erected before the excavation is made, as it also helps to hoist the soil out. The floor of the pit is sunk in sections a few feet at a time and cement applied to the walls. A lining of cement 1 to $1\frac{1}{2}$ in. thick is recommended, and a mixture of 1 part of cement and 2 to $2\frac{1}{2}$ parts of clean sharp sand is suggested as suitable. The green material is merely chaffed and allowed to fall into the pit, where it is trampled down. The expense of purchasing an elevator is thus obviated.

This type of silo has not been properly tried in Great Britain, but it has the merit of cheapness and there appears to be no obvious reason why it should not be a success.

Silage has been made in disused gravel pits at Roos Hall, Beccles. The sides and openings were roughly supported by wood and a chaff-cutter was placed on the side of the pit, which was then filled with chaffed green material. The whole was covered up with rough stuff and weighted down with heavy logs of wood. This method resulted in quite good silage, but there was much waste at the sides and entrance to the pit. Long maize was made into silage in this manner with fairly satisfactory results.

In deep pit silos there is some danger of poisonous gases developing, particularly where fresh green stuff has just been put in. If a lighted lantern is lowered into the silo, and continues to burn, it is safe to enter.

Trench Silage System.

For a number of years silage has been made in a trench at Colney, Norwich. This system possesses the great advantage that no capital outlay is required to cut and elevate the material. Samples of this silage were taken for analysis. They were excellent, both in appearance and composition (see p. 53).

In view of the excellence of the results obtained, it would appear that this method is worthy of very careful consideration by those who contemplate adopting the silage system. Silage is made in three trenches.

The largest is 25 yd. long, 5 yd. wide, and 4 ft. deep. This holds the produce of 50 ac. of lucerne in an average year. The sides of the trench have a slight slope to allow for the silage sinking and to keep the whole airtight. There is a gradual slope out of the trench at one end. The green unchaffed material is tipped into the trench until it gets level with the sides, when the horses draw over it as one would draw over a heap of farmyard manure. The whole is roughly levelled as the process continues. The men cart for two or three days, then leave it for a day and cart for two days more. Five or six acres are carted in a day. Two men are wanted at the heap, two men pitching, one man loading, and three men or women putting it into rows in the field. When the green material in the pit gets level with the ground, the empty carts go over it and this carting over it goes on as long as possible, as the more solid the heap is made the better. Carting goes on until the heap gets about 10 or 12 ft. high, or as high as possible for the horses to draw up the load. The sides are then cut and squared where necessary, and the whole heap is roofed up and at once covered with earth like a mangold heap.

It is most important to prevent access of air, so, in a few days, when the heap has sunk, if cracks appear in the covering earth, these should be made up with more earth. A thickness of 6 to 8 in. of soil is put on the heap.

Two of the trenches used are situated near the cow-shed and one in a field. The trenches are all somewhat similar in shape. One is 6 yd. wide and 17 yd. long.

The green material is usually left exposed to the sun for about a day in order to allow it to wilt a little before carting. If this is not done, and the material is very succulent, the silage, when finished, is apt to smell somewhat offensively. The silage is fed to the cattle unchaffed like hay. The soil where these trench silos are located is very light and there is no trouble from ground water. If a similar silo were made on heavy land, it would be necessary to arrange surface drains to take the water away. It is possible, but not certain, that on heavy land it would be an advantage to line the sides and floor of the trench with concrete. This would certainly keep out the soil water. There is very little waste in making silage in this way; in fact, the method appears to be so successful that, provided a suitable site can be found where there is no fear of the soil water getting in, it is difficult to justify the erection of expensive silos, especially when the cost of materials is so high.

The cost of excavating a trench of this type is not great, especially in sandy soil, and the work can be done at slack times.

"Clamp" Method of making Silage.

The writer has seen this method adopted very successfully with meadow grass. The loads of green grass are simply placed on the level

ground, like a manure heap, the empty carts being drawn over it, and the whole made as high as possible. When finished, the heap is covered with earth, after trimming the sides and ends. Sweet silage of excellent character is the result of this process. In one case this method was tried with green spring wheat which failed to ripen. The result was quite good silage in the centre of the clamp but a good deal of waste on the outside—doubtless owing to the open nature of the wheat straw.

The Stack System of making Silage.

Here the green material is carted into a heap with either a circular or rectangular base, and made as solid as possible. A horse walks about on this heap to help to solidify it, and the whole is built as high as convenient—usually about 6 or 7 ft. high when it is covered with earth. In this case there is a good deal of surface exposed to the air and some waste results. Sweet silage of fairly good quality has been made by this method.

Suitable Crops for Silage.

Mixtures of winter oats and tares are very popular as silage crops in East Anglia, and such mixtures would undoubtedly be found suitable in most parts of England. In the northern districts of England, in Scotland, Wales, and Ireland, and in any district in a high or exposed situation, probably spring-sown oats and tares would give better results, as the autumn-sown crop might not always stand the winter. Even in East Anglia and the Midlands, autumn-sown tares are sometimes badly stunted by cold and wet weather, especially on poor wet land. This was the case in 1916–7 and 1918–9. Usually however, the autumn-sown crop will give a better yield than the spring-sown crop in the drier districts of England.

As a rule a mixture of [illegible] bus. of tares and 1 bus. of oats will be found suitable. A few beans, say ½ bus. per acre, may be substituted for ½ bus. of the tares if desired, as they help to hold the crop up.

It is a good plan to plough in the beans with a shallow furrow when ploughing the stubbles, a few days before drilling the tares and oats. This gives them a start and makes them less likely to be smothered by the tares.

On heavy land all the manure required by the crop is a good dressing of basic slag or superphosphate, say 5 cwt. slag or 4 cwt. superphosphate. Farmyard manure is sometimes applied, but it is usually better to reserve it for other crops.

On light land 2 to 3 cwt. of superphosphate and 2 to 3 cwt. of kainit per acre will usually be found suitable if an ample supply of lime exists in the soil. If the soil is poor in that ingredient it would be desirable either to apply a dressing of lime or to use a neutral phosphate or even

basic slag instead of superphosphate, the same quantity of kainit being also applied. Under varying conditions it has been found that an average crop of green oats and tares is from 8 to 14 tons per acre.

Autumn-sown oats and tares will usually be fit to cut about the end of June or the beginning of July in southern and eastern England. At that time the seed is just beginning to form in the tare pods. Opinions differ as to whether it is better to cut the crop fairly early, or later when the crop is fairly mature.

American experts all seem to favour late cutting for maize, but the case of tares is rather different, and it seems that if they are allowed to become too ripe, the percentage of fibre will be higher. On the other hand, it is possible that more dry matter may be obtained by late cutting. This point requires investigation. If cut early, it will usually be desirable to allow the crop to remain in the sun for a day or so to wilt, or a rather considerable volume of liquid will ooze from the silo. In actual practice it is also a point of importance to cut the crop before heavy rains have beaten it down. If the crop is standing well about the middle of June, one may be tempted to cut it, even although it may be hardly mature enough. On light land a mixture of tares and rye may be found to give a good weight of green material.

Lucerne, in districts where it will grow well, is an excellent crop for ensilage purposes. There are two or three crops every year, it stands up well and hence is easy to cut, and there is no annual expense in seeding. The total weight of the two or three crops of lucerne growing in one year will usually equal or exceed that of a heavy crop of tares.

Sainfoin also makes good silage, although it has not been used very much for that purpose in this country.

Clover and Ryegrass, either alone or mixed, are excellent for ensilage, but as a general rule it will be found more convenient to make them into hay.

Second crop of clover may often be made into silage with advantage —it is usually rather difficult to make into hay, and the hay so made often comes out of the stack somewhat mouldy.

Other leguminous crops, such as Crimson Clover, Trefoil, &c., are quite suitable for ensilage. Meadow Grass is also excellent for the purpose, but it is perhaps better to make it into hay as a general rule where the climate is favourable. In western and damp districts it may be desirable to make grass into silage. Green maize has often been made into silage in East Anglia. There can be no doubt, however, that in an average season it does not mature sufficiently to make silage in the most economical way. It is too watery, and a considerable quantity of liquid drains away. However, if mixed with other material, such as partly dry second crop of clover, or grass, or even oat straw, this difficulty may be overcome to a considerable extent. In many seasons there

is a good deal of maize wasted, owing to early frosts, and this might very well be made into silage before the damage occurs. On certain types of light land maize grows remarkably heavy crops in suitable seasons, and it is a pity that no variety is known which might be tested to become sufficiently mature for ensilage purposes in this country.

Composition of Silage.

The following analyses of silage (p. 53) made under modern conditions have been performed by Mr. G. S. Robertson, M.Sc., and are published by his kind permission.

The difference in composition of the samples is undoubtedly due in the main to the different materials with which the silos were filled, and to the percentage of moisture present.

Changes and Losses taking place in the Manufacture of Silage.

Messrs. Arnett and Russell found that, in this country, in the manufacture of maize silage, the fibre present in the maize is practically unaltered in the process, the nitrogen free extract suffers most, the sugar disappears almost entirely, while the protein also suffers considerably.

American investigators state that the fundamental changes to which silage owes its keeping qualities are the conversion of the sugar present in the plant juice into acids which prevent the growth of putrefactive organisms, and into carbon dioxide which expels the oxygen of the air and prevents the growth of mould. It would appear from Dr. Russell's investigations that the changes occurring in ensilage are due to three agents—the living plant cell, the enzymes or unorganized ferments, and the micro-organisms.

Except in the case of maize—a crop which is not very suitable for ensilage in this country—the total loss of dry matter occurring in the silo has not been sufficiently investigated in Great Britain.

In a modern well-built tower silo American investigators claim that the total loss of dry matter may be as low as 7 per cent to 10 per cent. In their investigations loss owing to spoiled silage occurred chiefly at the top of the silo and at any point where air gained admission. Whether silage made under British conditions can show such a small loss as this is a matter which requires investigation. In comparing hay-making with ensilage, however, it must be remembered that in an uncertain climate hay-making involves considerable losses, and sometimes the hay is absolutely spoilt. It seems very likely that, taking this country as a whole, one-fifth of the total nutritive matter in the hay made is lost owing to bad weather, loss of leaf, &c. In the case of tares this estimate would probably be exceeded. Good tare hay can only be made in first-class weather. If the American figure of 10 per cent loss applies to crops such as tares and lucerne, when ensiled in this country, it appears

Materials used in making Silage.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Fibre.	Ash.	Method of Making.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	
Tares and oats	67·44	1·15	3·84	15·21	10·60	1·76	Cylindrical silo.
Tares and oats	72·30	1·14	4·96	9·75	9·43	2·42	Cylindrical silo.
Mustard, Tares, and chopped Oat Straw ..	78·03	0·97	3·09	6·57	9·09	2·25	Gravel pit.
Tares, Oats, Rye, and a little Wheat	69·43	0·84	3·17	11·05	13·29	2·32	Cylindrical silo (filled during very wet weather).
Green Maize	84·85	0·57	2·19	6·31	4·48	1·60	Cylindrical silo.
Green Maize	84·25	1·07	1·44	6·29	5·05	1·90	Cart shed.
Lucerne	78·53	1·67	3·96	6·07	7·32	2·45	Cylindrical silo.
Clover and Ryegrass ..	59·82	2·02	6·25	19·88	9·99	2·04	Cylindrical silo.
Meadow Hay	55·48	0·67	4·89	23·14	12·55	3·27	Cylindrical silo.
Lucerne	49·00	0·82	8·62	18·74	19·09	3·73	Trench silo.
Trifolium (Crimson Clover)	65·88	0·94	4·69	13·36	11·89	3·24	Trench silo.
Lucerne	62·39	0·98	4·81	17·08	11·88	2·86	Cylindrical silo.
Second Crop Clover and Meadow Hay, and Maize	68·06	1·30	4·80	11·53	10·41	3·90	Rectangular silo.
Tares and Rye	72·72	1·30	2·77	9·41	12·17	1·63	Cylindrical silo.
Tares, Oats, and a little Barley	73·72	2·68	2·89	8·39	9·68	2·64	Cylindrical silo.

likely that the losses in making silage are not any greater, if as great, as those involved in making hay. In the case of tares they are probably less.

Samples of silage made in the north of Scotland during the autumn of 1922 were selected for analysis at different dates throughout the feeding period. The following table gives the results obtained.

Contents.	Sample 1, 3rd Dec., Top Layer.	Sample 2, 21st Feb., 15 ft. from bottom.	Sample 3, 19th Mar., 9 ft.	Sample 4, 3rd April, 7 ft.	Sample 5, 23rd April, 4 ft.
Moisture	66·30	71·64	74·51	73·60	74·16
Soluble Albuminoids	0·40	0·812	1·88	2·50	2·30
Insoluble Albuminoids	2·87	2·875	2·23	2·21	1·58
Crude fibre ..	19·80	7·83	10·30	10·46	9·58
Fat and oil	2·30	1·55	0·88	1·30	1·18
Mineral Matter ..	1·70	2·73	2·48	1·95	2·90
Undetermined (carbohydrates, &c.)	6·63	12·563	7·72	7·98	8·30
	100·00	100·000	100·00	100·00	100·00

It will be noted from the above figures that on the whole there was little change in the composition of the silage from December to April, and from the top to the bottom of the silo. As was to be expected, the top layer contained slightly less moisture than those lower down. A notable feature was the gradual increase in soluble albuminoids with a corresponding fall in insoluble albuminoids. The other differences were probably due largely to differences in the composition of the original material ensiled.

Date.	Height at which temperature taken.						
	8 ft. 6 in.	20 ft.	30 ft.	40 ft.	50 ft. 18 in. inside silo.	50 ft. On top at centre.	50 ft. On top at wall.
	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.
21st Sept.	63	60	60	90	106	108	96
25th ,,	60	60	60	88	125	115	105
1st Oct.	64	61	60	84	112	108	84
5th ,,	60	56	56	84	105	104	74
10th ,,	58	56	56	82	108	108	70
15th ,,	59	56	56	84	111	109	71
20th ,,	59	56	55	74	106	110	72
25th ,,	58	55	54	76	104	113	72

During the period of storage and prior to the commencement of feeding the silage from which the above-mentioned samples were drawn, temperatures were taken regularly at various points in the silo (see table on p. 54). Though the figures vary considerably from place to place they are remarkably consistent throughout the period.

The Feeding of Silage to Stock.

A large number of farmers have now had an opportunity of testing the effects of feeding silage to stock under ordinary farming conditions. Probably in Suffolk alone there are sixty or seventy silos each holding 100 tons or more of silage, and in all cases the results of feeding the material have been satisfactory.

The silage made in East Anglia is chiefly used as a food for milking cows. Provided reasonable care is used in feeding, there is practically no danger of the milk acquiring an objectionable taint. Quite a considerable proportion of the milk consumed in Norwich, Felixstowe, and Ipswich is produced by silage-fed cows, and no cases of tainting have been noted. A considerable quantity of milk produced by silage-fed cows is sent to London. Several members of the East Anglian Milk Record Society feed their cows upon silage. The milk given by these cows is regularly tested for butter fat and does not prove abnormal in any way.

Silage has also proved an economical milk producer. Thus in an inquiry conducted by the recorder of the East Anglian Milk Record Society in 1916–7, it was found that the herd which produced milk at the lowest cost per gallon, amongst members of the society, was partly fed upon silage. The herd in question consisted of pedigree Friesian cows. They received an average daily ration of 37 lb. of mangolds, 50 lb. of silage, 2½ lb. of ground oats. The quantity of concentrated food was varied for each cow, according to the amount of milk given. The cows gave an average of 3 gall. daily. No doubt the excellence of the cows had a considerable influence upon the yield of milk and consequently upon the cost of production per gallon, but it is also probable that the feeding had some effect.

In an experiment it was found that 60 lb. of silage gave similar results to 60 lb. of mangolds plus 7 lb. of chaff in the production of milk.

It was further found that in feeding a daily ration of 60 lb. silage, 24 lb. turnips, and 1·6 lb. maize gluten to Red Poll cows, milk was produced at a very cheap rate. Silage has also given excellent results in Ireland as a food for milking cows and young stock. In order to avoid all chance of any odour of silage getting into the milk it is well to feed the silage just after milking.

Silage has proved a very useful food for young stock in Suffolk, and some of the cattle fed upon it have made extremely high prices at recent

sales of pedigree animals. It has also been found suitable for fattening bullocks.

As a food for horses, sheep, or pigs silage has not been very widely used, but three cases have been observed where it has been fed to horses —all with good results. It is important that there should be no mouldy material amongst that fed, and this is especially so with brood mares.

Pigs have been found to eat the maize and tare silage with avidity, and it is undoubtedly useful in small quantities as a substitute for roots for these animals. American experience indicates that silage is not a very suitable food for fattening pigs, as it is too bulky. It appears probable that for store pigs, sows, &c., it would be a valuable addition to other foods, but it is obvious from its bulky character that it would not be desirable to feed it to fattening pigs in very large quantities.

Poultry have been fed successfully on silage—in this case as a substitute for green material.

There has not been a great deal of experimental work conducted with silage in this country. There exists, however, sufficient experimental and farming experience to show that silage is fitted for all classes of farm stock if given in moderation. British farmers usually feed from 30 to 50 lb. of silage daily to milking cows or fattening bullocks, and with other foods this is probably a suitable quantity. It is generally fed in conjunction with roots, hay, straw, and concentrates.

The Board of Agriculture's leaflet No. 9 makes the following suggestions:

" For cows no hard and fast rules can be laid down, but the two following rations are suggested for average dairy cows weighing about 10 cwt. and yielding 2 gall. of milk:

" *Ration 1.*—Oat and tare silage, 20 lb.; mangolds, 56 lb.; straw chaff, 8 lb.; bran, 3 lb.; cake and meal, 5 lb.

" *Ration 2.*—Oats and tare silage, 50 lb.; meadow hay, 7 lb.; cake and meal, 5 lb.

" For fattening cattle between $2\frac{1}{2}$ and 3 years old a ration containing 28 lb. oat and tare silage, 84 lb. mangolds, 10 lb. oat straw, and 4 lb. mixed linseed and coco-nut cake has given good results.

" For store cattle, about 15 months old, a ration containing about 35 lb. oat and tare silage, 8 lb. straw chaff, 2 lb. mixed cake has proved successful and kept the stock growing well. If all the roots are replaced by silage it will be necessary to supply the cattle with water."

Very few analyses of silage made under British conditions are available. It is evident, however, that silage more nearly resembles grass or green material than it does any other farm foodstuff. It also resembles hay, except that it contains three times as much water. It contains

nuch more dry matter than roots and more fibre and albuminoids, but t does not contain as much of the sugar which renders roots so valuable . food.

The following analyses by Dr. Crowther form a basis for comparison:

	Oat and Tare Silage, average sample.	Pasture Grass.	Mangolds.
	Per Cent.	Per Cent.	Per Cent.
Moisture	70	80	88
Albuminoids ..	3½	3	1¼
Oil	1	¾	¼
Carbohydrates ..	12	10	9
Fibre	10	5	1

GENERAL PROSPECTS OF ENSILAGE IN GREAT BRITAIN AND IRELAND

The great interest at present taken in ensilage seems likely to be ɔermanent. It is founded on the sound principle that arable land under green crops can produce much more food per acre than grassland, hence more stock can be kept on the same farm. This means a higher standard of productivity. It is not likely that silage will replace roots on good root-growing land in a suitable climate, but, where roots are difficult to grow, silage possesses many advantages. Oats and tares are a very easy crop to grow; they will succeed on poor land and do not require much manure—a dressing of basic slag or superphosphate being all that is wanted as a rule.

Lucerne and sainfoin, in districts which suit them, are extremely productive and require very little labour and very little manure. It appears probable that lucerne would grow satisfactorily in quite a number of midland counties in which the area under that crop at present is almost negligible. Once a plant of lucerne is established the only manurial treatment it requires is a good dressing from time to time of basic slag on heavy soils, or phosphates and potash on lighter land; wet undrained soil is, however, fatal to it. Lucerne is also very productive on poor light land, provided there is sufficient lime and potash present for its requirements. There is little doubt that much of our derelict light land might be transformed into fairly productive soil by chalking, the addition of potash, and the growth of lucerne, which could be utilized as silage and hay.

A good plant may be confidently relied upon to produce two or three times as much green stuff per acre, on poor land, as would be given if the land were under grass. Ensilage enables this material to be utilized to the best advantage even in a showery district.

In the wetter districts of Great Britain and Ireland modern ensilage methods will undoubtedly prove very useful in the preservation of grass for winter use. A judicious extension of the ensilage system is likely to be of considerable benefit to agriculture in this country, and it is especially likely to help the occupiers of poor land, both heavy and light, in keeping their holdings under the plough and so rendering this country less dependent upon foreign sources for its supply of foodstuffs.

HOPS

By A. H. BURGESS

Botanical Features

The hop belongs to the natural order Cannabaceæ and is closely related to the nettle family. It has been commonly stated that only one species of hop exists,[1] viz. *Humulus Lupulus*, Linn., indigenous to Europe, from which all the cultivated varieties of hops have originated. According to the investigations of Salmon and Wormald[2] a second species exists, viz. *Humulus americanus*, Nuttall, native to North America, from which the American commercial varieties have probably been derived.

The common hop is a perennial herbaceous plant. The root system is extensive and, on suitable soil, the main roots will penetrate to a depth of 10 or 12 ft., while the lateral ones may cover an area 6 to 8 ft. in diameter. This large feeding area is very necessary, for, during the months of May and June, the perennial underground portion of the stem (rhizome) produces a luxuriant growth of stem and foliage. The plant grows to a height of 13 ft. or more during this period and naturally requires an abundant and continuous supply of food and water.

The stem (" bine ") is hollow, hexagonal, $\frac{3}{8}$ to $\frac{1}{2}$ in. diameter and of a greenish or purplish red colour. The end of the growing stem moves round in a circle, in a clockwise direction, thus encircling any support with which it comes in contact. It is furnished with short, spiny, hooked hairs (fig. 1) which enable it to cling to the support and prevent it from slipping down. In the autumn the stem withers and dies to within a few inches of the ground, the food material in the stem being passed down to the root-stock and base of the stem for use by the young shoots in the succeeding spring. Besides these long aerial stems the rhizome

[1] The Japanese Hop (*H. Japonicus*, Sieb. et Zuer.) is an annual plant grown for ornamental purposes in gardens. It has no brewing value.

[2] *Journal of Botany*, May, 1915.

also produces underground stems, or "runners", which must be removed annually to prevent the plant from spreading.

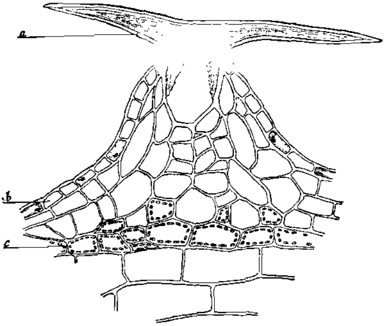


Fig. 1.—Hooked Climbing Hair of Hop Stem

a, Wall of hair cell; *b* Epidermal cells of stem; *c*, Chlorophyll granules.

(The author is indebted to Mr. W. M. Ware, M.Sc., for this illustration)

The leaves are opposite and are borne on petioles about half the length of the leaf. Their shape is irregular but roughly cordate with, usually, three or five palmate lobes; the margin is acutely serrated. The membranous stipules are united with those of the opposite leaf. The petiole and main veins of the leaf produce hooked hairs similar to those found on the stem. Numerous resin glands are scattered on the under side of the leaf.

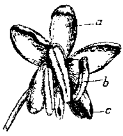


Fig. 2.—Male Hop Flower (×8)

a, Lobe of perianth; *b*, Anther; *c*, Slit from which pollen has escaped.

The hop plant is diœcious, i.e. the male and female flowers are borne on separate plants, but very occasionally a plant is found producing flowers of both sexes. The inflorescences of the male plant are much-branched panicles arising in the axils of the leaves on the main stem and its lateral branches (fig. 2). The flowers are small (about $\frac{1}{4}$ in. diameter) with a single perianth of five segments; five or more stamens carry anthers, about the same length as the perianth lobes, on very fine filaments. The anthers dehisce by two slits at the sides and near the end, liberating the pollen, which is carried by wind to the female flowers.

Fig. 4.—Mature hop cone

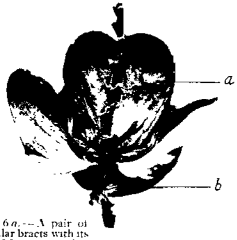


Fig. 6 *a*.—A pair of stipular bracts with its set of four bracteoles; *a*. Bracteole; *b*, Stipular bract

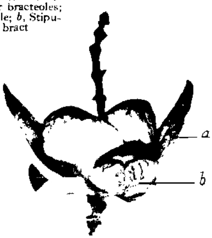


Fig. 6 *b*.—The same, from other side

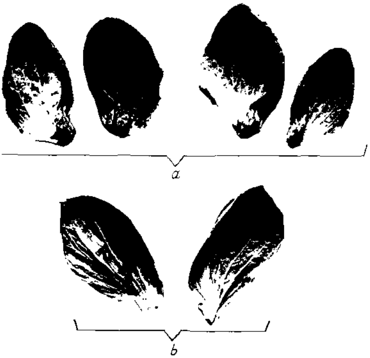


Fig. 5.—*a*, Bracteoles containing fruits. Showing lupulin grains at base; *b*, Stipular bracts

Fig. 7.—A pair of stipular bracts with rudimentary leaf arising between them

The female inflorescences are borne on peduncles (fig. 3), which are often branched, arising in the axils of the leaves on the lateral branches and also in the axils of the upper leaves on the main stem. The inflorescence consists of a central axis bearing a number of small membranous bracts. These are of two kinds, stipular bracts and bracteoles. The former are pointed and arranged in alternate pairs on opposite sides of the axis; they are vestigial structures representing a leaf, the petiole and blade of which are absent. In some varieties, however, when heavily manured with nitrogenous fertilizers, the leaf itself develops (figs. 4, 5, 6 *a* and *b*, and 7). Above each pair of stipular bracts a very short branch arises carrying four minute bracteoles with a female flower at the base of each. These flowers are very small structures consisting of a cup-shaped perianth containing a superior ovary which carries two long papillated stigmas. When in full bloom the stigmas protrude far beyond the bracts, giving the inflorescence a brush-like appearance—the hop is then said by the hop grower to be in "burr". The flowers will remain in this state for a week or fortnight, provided that no pollen from the male plant reaches them; if, however, fertilization takes place, the stigmas rapidly wither away. As the stigmas are very susceptible to infection by the spores of hop mould, the burr stage is a critical period and fertilization is advantageous in that it shortens this. When the stigmas have withered, the bracts and bracteoles rapidly develop and, at the same time, the axis lengthens. The plant is then "in hop". Bracteoles containing fertilized flowers and their adjacent stipular bracts grow much larger than those whose flowers received no pollen, and the "seed" (fruit) adds weight to the hop; fertilization thus increases the crop. The inflorescence at this stage has a cone-like appearance (strobile).

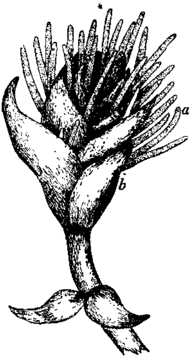


Fig. 3.—Female Hop Inflorescence (×13)

a, Papillated stigma; *b*, Stipular bract.

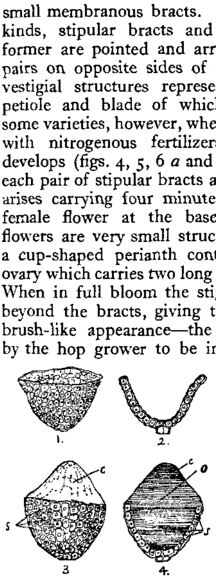


Fig. 8.—Lupulin Gland of the Hop (magnified)

1 On very young hops in "burr" stage. 2. Vertical section of 1. 3. Fully developed gland; *s*, secretory cells; *c*, cuticle. 4, Vertical section of 3: *s*, secretory cells; *c*, cuticle; *o*, cavity filled with resin and oily contents.

(Reproduced by permission of the publishers of Percival's *Agricultural Botany*)

As the bracteoles grow, small resin glands develop upon them (fig. 8), especially near the base; these are also produced on the perianth of the flower and, to a small extent, on the stipular bracts. The glands (Lupulin granules) secrete the resin and aromatic oil for which the hop is cultivated. The cones, which constitute the "hops" of commerce, are allowed to remain on the plant till their resin content is at a maximum. The glands are attached to the bracteoles by a very delicate connection and are easily rubbed or shaken off; great care must therefore be exercised in handling the crop after picking or much of this valuable material will be lost.

Historical Summary

Humulus Lupulus is a native of Europe and is probably indigenous to the south of England. Many of the so-called wild hops, however, are simply escapes from cultivation.

Until about 1300 the cultivation of the hop remained chiefly in the hands of the monasteries. It appears to have been used largely for medicinal purposes; but about this time hopped beer came into general use in Germany and the hop gardens became more widely distributed. The first hopped beer used in this country was imported from the Continent.

Cultivated hops were introduced into Kent from Flanders at the beginning of the sixteenth century, but their use in brewing was at first not appreciated. Both Henry VII and Henry VIII forbade the use of hops in beer brewed for the Royal household; the citizens of London also petitioned Parliament to prohibit their use "as they would spoil the taste of the drink and endanger the people". This, however, appears to have had little effect, for, in 1552, numerous hop plantations had been formed. The first book on English hop-growing was written by Reynolde Scot and published in 1578, *A Perfite Platforme of a Hoppe Garden*. The illustrations in this book show the hop plants growing on small heaps of soil, and, although no longer grown in this way, the positions in which the hops are planted are still known as "hills".

At the beginning of the seventeenth century hops were produced in abundance for the preservation of beer.

In 1711 a duty of a penny per pound was placed on hops, which discouraged their growth in the less favourable districts. The duty was repealed in 1862, and the industry was consequently stimulated.

J. Mortimer[1] gives detailed directions for the cultivation of hops, and these are essentially very similar to those followed at the present day. W. Marshall[2] mentions the use of bins, into which the hops were

[1] *The Whole Art of Husbandry*, 1716. [2] *Rural Economy of the Southern Counties*, 1798.

picked, and also improvements in the method of drying the hops. Charcoal and coke were used as fuel and sulphur was thrown on to the fires during the process.

About 1850 the oast houses were much improved by building the kilns higher and placing the drying floor at a greater height above the fire; many kilns built at this period are still in use.

Varieties of Hops

The following list of the best-known commercial varieties of hops grown in this country, together with their more important characteristics, compiled by A. Amos and E. S. Salmon, is quoted from the *Journal of the Ministry of Agriculture* (Vol. XXIX, No. 1, p. 33).

Early Varieties

Prolific.—The earliest hop, with very large cones which are easily picked; crops heavily. Little grown on account of its poor quality.

Amos's Early Bird.—Ripens a few days before the Bramling. Suitable for the best loams and greensands; grown in parts of Kent and Hampshire and considerably in Herefordshire and Worcestershire. This variety, like the Bramling, is liable to be adversely affected by a cold or wet summer, when the cones may be small and difficult to pick. Highest quality.

Bramling.—This variety is universally grown on the best soils throughout the hop-growing districts, but its acreage is unfortunately declining. Highest quality.

Mid-season Varieties

Tolhurst.—Largely grown in certain districts; grows vigorously on nearly all soils, crops very heavily, and is easily picked. Quality poor. This is a favourite variety on account of its cropping powers, but is coming into disfavour on the market on account of its lack of good brewing properties.

Mathon.—Grown only in Herefordshire and Worcestershire on the best loamy soils; in some seasons inclined to make too much bine, which is not fruitful and consequently difficult to pick; keeps well when healthy. Highest quality.

Cobb's.—Grown largely, especially in Kent, on loam and the lighter soils; grows vigorously and crops heavily; easy to pick, but does not keep well. Medium quality. This is a good commercial variety.

Tutsham.—Very similar to the above, with better keeping powers. In order to counteract the tendency of this variety to produce, on strong soils, too much bine, it is the practice in some districts to pull the hills

very hard and to train up only the latest bines. This is a good commercial variety.

Farnham Whitebine.—Grown only in Hampshire and Surrey, on good loams. Highest quality.

Fuggle's.—Most suitable for heavy clay soils; grown almost to the exclusion of other varieties in the Weald of Kent and Sussex. Has a vigorous constitution, but is inclined to produce little bine unless stimulated by heavy nitrogenous manuring; crops very heavily in average seasons and does well in wet seasons, but suffers in dry summers; easy to pick; keeps well. Is a very good " cropper " hop, and an excellent commercial variety for heavy soils.

Rodmersham Golding.—Not grown except in a few districts in Kent on good loams. Has a weak constitution, and the hills are liable to die away from " canker ". Easy to pick. Highest quality.

Late Varieties

Petham Golding and Canterbury Whitebine.—Only grown on the best loams, chiefly in Kent. Frequently grow too much bine, and in wet summers develop only a small crop. Highest quality. Although the quality is second to none, the area devoted to the cultivation of these two varieties is now small.

Colegates.—The latest hop; grown on heavy land, chiefly in the Sussex Weald and in Herefordshire. Crops heavily, but the cones are small. A " cropper " hop.

Cultivation of the Hop Crop

Distribution.

The chief hop-growing countries are Germany (31),[1] England (27), United States (26), Czecho-Slovakia (19), France (11), and Belgium (5). The acreage under hops in this country was 36,600 ac. in 1914; this was reduced in 1917 to 16,900 ac., the land being required for the production of other crops. In all of these countries the hops are localized in well-defined areas; in England the acreage is distributed among only five counties, viz. Kent, Worcestershire, Herefordshire, Hampshire, and Sussex, and even in these counties it is restricted to certain areas. The reason for this localization appears to be mainly climatic. Soils similar to those on which the hops thrive occur in many other districts; when hops have been tried in some of these localities, however, they have not proved a success. In the actual hop-growing areas, moreover, some varieties will only thrive in certain parts. It must also be borne in mind that hops are a very specialized crop, and skilled labour is required in

[1] The estimated acreage, in thousands of acres, 1922.

many of the operations connected with their growth. This labour is generally unavailable in districts remote from the hop-growing areas, which fact constitutes a contributory cause of the localization of the crop.

Climate.

The hop requires a mean summer temperature of about 60° F. Sudden changes are detrimental to growth, and cold periods in June or July, when the bine is nearly full grown, are especially harmful. Frosts during September, when the hops are being picked, cause the cones to turn brown and lose their attractive appearance very quickly.

Wind is one of the enemies with which the grower has to contend, and is most harmful during the later stages of growth. The bracts when blown about become bruised and brown at the edges. A strong wind will also do much damage to fully grown hops by breaking the supports, which are already burdened with the weight of the crop; sometimes the entire structure may be brought to the ground, entailing great loss to the grower. A sheltered position is therefore essential, and if no natural wind-break exists one should be formed by planting a row of poplars, or other quick-growing trees; or, alternatively, matting screens ("lewing") may be erected on the windward sides of the garden.

With regard to rainfall, the hop requires a plentiful supply of water during May and June, in which period it makes very rapid growth. August and September should be dry in order that the hops may ripen and be picked quickly.

Soil.

The hop requires a deep soil well supplied with lime and organic matter, and an open subsoil. The drainage must be good in order that thorough aeration may induce abundant and healthy root formation—stagnant water is fatal to the hop. Alluvium resting on a porous subsoil is ideal for this crop, but it may be grown on a variety of soils ranging from loam to well-drained clay. Light soils and heavy clays are unsuitable.

Preparation of the Land.[1]

If the land is under grass it should be fed off closely with sheep and then ploughed two furrows deep in the autumn. A subsoiling plough should follow in the second furrow.

In the case of arable land the autumn ploughing should be 8 or 9 in. in depth, a subsoil plough following to break up the soil consolidated by continued ploughing.

[1] The cultural operations described refer more especially to the county of Kent.

The land is then levelled by harrowing before setting out the positions of the plants.

Setting Out.

The hops are planted in rows 6 to 7 ft. apart, the plants also being 6 to 7 ft. apart in the rows. The width of planting is determined by the variety to be grown and the nature of the soil and climate. With weak-growing varieties on poor soils 6 ft. square allows ample room, while strong varieties on good soil will require quite 7 ft. In years when the crop is small the more closely planted hops produce a larger crop than the widely planted ones, and in such years the value is greater owing to the general shortage. In years favourable to growth, however, the more widely planted hops produce a larger crop of better quality.

The width of planting having been decided, the next step is to mark the positions of the hills with short sticks; this must be very carefully carried out. The rows must be perfectly straight and the plants accurately at right angles with those in the other rows, in order that they may be situated in the correct positions with relation to the overhead wires to which they will be trained. Straight rows are also necessary to minimize injury from tillage implements and spraying machines.

Propagation.

The hop plant can be reproduced either by seed or by means of cuttings taken during the dormant period. The former method is never employed commercially, for the seedlings produced are a very mixed collection—about half are male plants and the majority of the remainder are practically worthless. In addition, the seedling female plants do not produce a crop until they are four or five years old. This method is therefore only used with the object of producing new varieties, the parent plants being carefully selected in the endeavour to combine desirable characteristics in their offspring.

Hop-growers propagate the plant solely by means of cuttings, thus ensuring new plants identical with those from which they were taken. The cuttings are taken during the autumn or spring; they are the basal portions of the preceding season's bines, on which the formation of adventitious roots has been induced by placing earth around them in June. After raking away the earth from the plant the stems are cut off within ½ in. of the root-stock, close under a pair of buds. The upper portions of these stems are then removed just above the third or fourth pair of buds. A cutting, or " cut sett ", is thus produced 3 or 4 in. long and ½ in. in diameter. Only the strong cuttings should be saved for planting. The best are usually obtained from plants in their third or fourth year of growth.

The cuttings should be planted as soon as possible after removal

from the plant and should not be allowed to become dry. Although they may be planted in their permanent positions, the usual and better practice is to grow them in nursery beds for the first year. The one-year-old plants are known as " Bedded Setts ". If they are allowed to remain in the beds for two years the plants are called " Stags "; they are, of course, larger than the " Bedded Setts " but should be avoided as they do not transplant well.

Planting.

A variety, or varieties to provide a sequence of picking, suitable to the district having been chosen, setts are raised, or bought and laid in soil until required. These may be planted at any time from November to March; the usual time for planting is, however, during a fine period in January or February. Holes about 9 in. square and 6 in. deep are dug beside each stick to receive the setts. A forkful of well rotted dung, or a little shoddy, may be mixed with the soil in the bottom of the hole before planting. A little superphosphate or basic slag is sometimes used in the same way, to promote root formation.

If the setts are strong it is necessary to plant only one in each position (hill), if weak, two or three are planted together. The sett, after trimming off any injured roots, is placed in the hole close beside the stick, the roots are spread out, and the top of the sett brought level with the surface of the soil. The hole is then filled in and the stick replaced so that it *slopes* over the planted sett, thus indicating the position and the fact that a sett has been planted, the top of the set being very inconspicuous.

Male plants which flower at the same time as the female variety should be planted at the rate of 1 to every 200 females. It has been shown that a pollinated hop will grow out considerably larger than one which is unfertilized; it is even possible to pick out the bracts containing seeds in a partially seeded cone by their more complete development, without breaking open the cone. The crop in this way, and by the " seeds " produced, is increased by some hundredweights per acre. Fertilization is also beneficial in shortening the critical burr stage, when infection by mould may be disastrous. It must, however, always be borne in mind that the seeds themselves are of no use to the brewer, who is naturally unwilling to pay such a high price for hops containing a large amount of this useless material.

Systems of Training.

A pole, about 8 ft. long, is placed at each hill after planting; this will be sufficient to support the bines during the first season. In their second year the plants will grow to their normal height and will require supports 12 to 14 ft. high according to the variety and soil.

The old method, which is still in use in many parts, is to train the bines up poles. Two or three poles are placed at each hill, the tops of all the poles being connected with strings passing from one to the other and serving to keep the poles in position and also as a horizontal support for the bine when it grows beyond the poles.

The majority of growers, however, now train their hops up coco-nut fibre strings, which pass from the hills to a network of wire, supported at a height of 12 to 16 ft. on stout poles. There are three types of wire-work, the "umbrella", "Butcher", and "Worcester", each of which has many modifications. The wire used is twisted strand wire, different gauges being employed according to the strain the particular wire has to bear.

The Umbrella System.—In the umbrella system (fig. 9), wires,

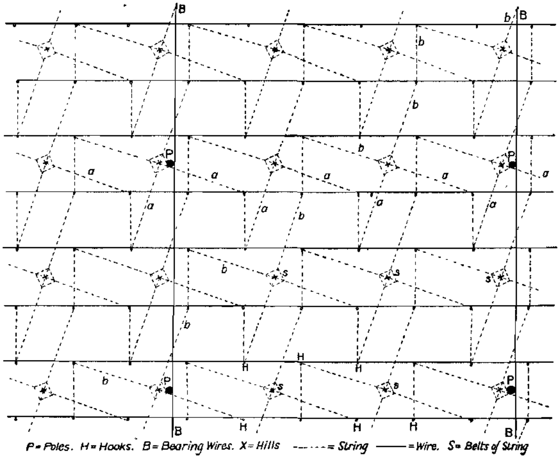


Fig. 9.—The "Umbrella" System of Training

parallel to and twice as many as the rows of hops, are supported at intervals by stouter cross wires, or "bearing" wires, which pass under them at right angles and are borne on poles (there is usually one pole

to every six hills in this type of wire-work). The ends of the former are fixed to very stout " main " wires carried on substantial poles along the headlands at opposite ends of the garden. Every wire is stretched tightly by means of a wire strainer. All the outside poles in this, as in other wire-work systems, are anchored by wires to logs of wood buried in the ground. Hooks are attached to the parallel wires, each wire carrying twice as many hooks as there are hills in the corresponding row of hops. The hills are arranged to come midway between the parallel wires and midway between the hooks on these wires, as shown in the diagram. A wire hook, or wooden stump with a nail driven in to serve as a hook, is placed at each hill.

The string is put on to the hooks by means of a stringing pole—a light pole about 7 ft. long, fitted with a bent tube at the top and an eye about 2 ft. from the base through which the string runs. The ball of string is carried by the stringer in a bag and is used in one continuous length. The arrangement of the string is shown in the diagram, which represents a garden strung on the umbrella system, viewed from above. It will be noticed that there are four strings to each hill, one attached to each of the four neighbouring parallel wires, the hooks over which they pass forming the corners of a square. The hills are first furnished with two strings each (*b*, *b*), the stringer passing diagonally across the garden; the other two strings (*a*, *a*) are then added, the stringer passing up and down the rows of hops. The four strings from each hill are then tied in with a belt of string, forming a square with about 9-in. sides, at a height of 4 to 5 ft. from the ground; this keeps the alley (i.e. the space between the hop rows) clear for cultivation and spraying.

This system provides good exposure to air, and the hops can be cultivated and washed in both directions. The hops when growing luxuriantly tend to shut out the light from the lower parts of the stems and thus prevent the proper development of cones in these shaded places. Hops trained in this way are also very liable to wind damage unless well sheltered.

The Worcester System.—The wire-work of this system is the same as that used in the umbrella system; it differs, however, from the latter in the arrangement of the string and in width of planting. The wire-work is also usually carried at a greater height—15 to 17 ft.

The hills are planted 3 to 3½ ft. apart in the rows; about double the number of setts used in umbrella or Butcher work are therefore required where this method is to be employed.

Only two strings are placed at each hill; these pass from a hook or peg at the hill to the two nearer parallel wires in the adjacent alleys, their ends being attached to these wires at the diagonally opposite corners of a square over the hill, the side of which is the width between the two wires. The centre of the alley is thus left open. The slope of the string

is much less than that of the umbrella system, and, consequently, the *bine climbs readily without so much* hand *training*.

The hops can be easily washed and are well exposed to light and air. A disadvantage of this system is that cross-cultivation is not possible.

The Butcher System.—This was the first system of wire-work used in this country and is still largely employed in East Kent (fig. 10). The poles are placed in the rows of hops midway between each other hill; on these poles three horizontal wires are supported. The lowest

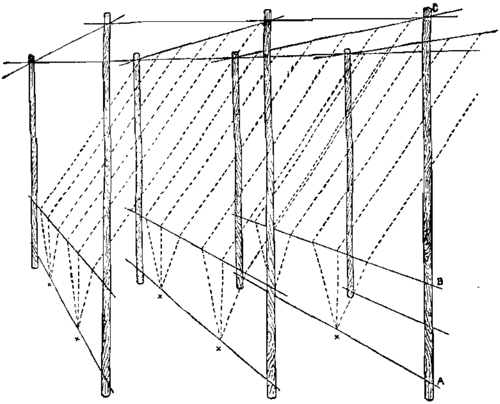


Fig. 10.—The "Butcher" System of Training

X = hills; A = low wire; B = "breast" wire; C = top wire

wire is 6 in. to 1 ft. from the ground, the middle or "breast" wire at a height of 4 to 5 ft., and the top wire is fixed near the tops of the poles.

The strings are attached to the low wire above each hill; these diverge and are attached to the breast wire at equal distances apart. They then pass at a slope, parallel to one another, over the alley and are attached to the top wire above the neighbouring row of hops. They are generally tied to this wire by a man mounted on stilts. The slope is, if possible, away from the direction of the prevailing wind; there is then less likelihood of damage.

The strain on this type of wire-work is mainly in one direction (opposite to that in which the strings slope); special care should therefore be taken

to connect the tops of the poles by stout cross wires at right angles to the string-carrying wires, and also to very securely anchor the poles on the side of the garden towards which the strings slope.

Hops trained on the Butcher system are well exposed to sunlight, develop their hops well, and will stand well against wind. Owing to the fact that all the bines lie in one plane, they are easily washed. But they are liable to become somewhat matted together, and the hops may be shattered if special care is not taken when pulling them down for picking. Cross-cultivation is not possible owing to the presence of the breast wire.

Tillage Operations.

Potatoes or mangels may be grown in the alleys the first year without harm to the hops, provided that the crop is well cultivated and manured. If, however, the land is weedy no crop should be grown.

The ordinary cultivation commences in the second year. The land is ploughed in the autumn, the furrows being thrown toward the row of hills, which thus occupies the centre of the ridge; the open furrow, which is left down the centre of the alley, serves to carry off superfluous water from the winter rains. A modification of this autumn ploughing is practised in some districts. During the latter part of August, just before the hops are picked, a ridging plough with specially extended mould boards is run down the centre of each alley, producing a ridge and furrow surface similar to that formed by the ploughing mentioned above.

In the spring the land is again ploughed; this time the furrow slices are thrown toward the centre of the alley, away from the row of hops. The centre furrows are deep, and the depth of ploughing is progressively decreased as the rows of hops are approached in order that the roots may not be unduly damaged.

The hills are thus left on a narrow strip of unploughed land. This strip is dug with a three-tined digging fork and the earth scraped away from the hills with a small hoe to expose the crown of the hill for cutting or " dressing ".

During the growing season the land is cultivated from time to time, at first deeply, gradually diminishing the depth until July, when it should be just sufficient to provide a mulch and keep down weeds. The land should not be touched or only shallow hoed after the hops are in burr.

The soil near the hills is hand-hoed periodically. The hills are earthed up slightly about the end of June.

Dressing.

The hills having been opened, the previous year's stems are cut off with a sharp knife to within about half an inch of the root-stock, leaving about two pairs of buds. The strongest of these cuttings may be used

for the production of setts if required. The underground runners are removed from the hill at the same time; these may also be used for propagation.

As each hill is dressed the soil is raked back over it. The operation should be completed before the end of the first week of April.

Young hops are dressed earlier than old established ones; January or February is a suitable time. They should also be cut a little farther from the root-stock—about an inch.

The objects of dressing are: (i) to restrict the number of shoots, which are thus strengthened by receiving the entire food supply; (ii) to keep the root-stock below the surface at a sufficient depth for protection from frost; (iii) to prevent the plants from spreading into the alleys and producing suckers.

Training.

After completion of dressing the string is put on to the wire-work, using a stringing pole where hooks are employed on the top wire or stilts when the string is tied directly to the wire. Coco-nut fibre string (coir yarn) is always employed in this country; it should weigh about 1 lb. per 100 yd., and 1 cwt. to 1½ cwt. will be required per acre. This, unlike ordinary string, stretches when wet and shrinks on drying. For this reason, when stringing is carried out in dry weather, it is usual to soak the balls of string before use so that it will remain tight during rainy periods.

In May, when the shoots are 1½ to 2 ft. high, the coarse ones with long internodes are removed by pulling, these being less productive than the finer bines. Only a few of the coarsest shoots are removed from hops of the early varieties, and in the case of young hops (1 year old) all the strong shoots are allowed to remain to strengthen the plant.

The remaining bines are then twined up the strings in a clockwise direction—opposite to that of runner beans—great care being taken not to break off the brittle tips. The stems become more flaccid when they have been exposed to the sun for a few hours, and the risk of damage is lessened if the training is carried out when they are in this state. Two bines are usually put to each string, but in some weak-growing varieties two and three bines are put up alternately. It is necessary to work through the garden two or three times at intervals of a week or ten days before all the strings are properly furnished. The surplus bines are then pulled out—as are any others that may arise later in the season.

The work of training is usually performed by women.

Stripping.

At the end of June or beginning of July the plants will have developed large leaves and some lateral branches on the lower parts of the bines.

These form a home for aphides and mould, and are scarcely touched by wash from an ordinary sprayer. They also check the free circulation of air through the garden and hinder cultivating operations. It is therefore advantageous to remove them up to a height of about 5 ft.

If the plants are growing freely the stripping may be done in one operation. It was shown, however, by Sir A. D. Hall, when principal of Wye College, that this weakens the plant to a certain extent and, in seasons unfavourable to growth, causes a reduction in crop. He advised that in such seasons the stripping should be conducted in two operations with an interval of about a fortnight.

Manuring.

The hop plant responds to liberal manuring. A very large quantity of vegetable matter is produced by the hop in a comparatively short period. The food supply must therefore be plentiful and continuous, particularly during May, June, and July. As with other crops, the intrinsic characteristics of the soil must always be considered when arranging the system of manuring to be adopted.

The following extract,[1] in which Sir A. D. Hall sums up a number of the results obtained from manuring experiments which he carried out on hops, gives a concise account of the requirements of the crop in this respect:

" The results of the manurial experiments in 1902 all go to strengthen the conclusion we had begun to form a year or two ago, that the hop plant is one which shows no special requirements in one direction or another, but is an all-round feeder. It is not like the swede crop, which shows a special dependence on a free supply of phosphates, or potatoes, which particularly need plenty of potash; but the hop requires what may be termed a normal mixture of all the elements of plant food.

" The problem of manuring hops satisfactorily, then, resolves itself more into a study of the soil. Each type of soil has its own characteristics which do not hold for other soils. For example, on the clay at Marden and Oxted our experiments have shown that phosphates ought to be freely used, but potash is not wanted; *per contra*, at Farnham and at Frant phosphates give no special return, but potash dressings increase the crop. At Farnham, again, lime is specially wanted, and at Selling there is no striking deficiency to be made up of any of the mineral plant foods.

" In earlier days, when a much smaller crop of hops was generally grown, it was sufficient to supply the land with an almost exclusively nitrogenous dressing, such as shoddy, or rape-dust, or dung (which is effectively a nitrogenous manure). Supplied with nitrogen, the plant

[1] *Journal South-Eastern Agricultural College*, 1903, 12, 29.

was able to obtain its minerals for itself from the reserves in the soil; but latterly, when much larger crops per acre are grown, it is not enough to rely on nitrogenous manures alone: the mineral constituents of the soil cannot come into action quick enough to fully feed the crop, hence the need of supplementing the nitrogenous manure with a certain amount of mineral manure also.

"On the typical hop soils, the deep loam and brick earths of East and Mid Kent and Farnham, these mineral manures need not be large in amount nor specially compounded, for such soils are well mixed and naturally contain all the elements required. It is where the crop has spread on to soils less suited to its development, on the clays, the sands, and other soils with a special rather than a general character, that the particular requirements of the crop must be studied by experiment and analysis, and where these investigations are in the end likely to be of most service."

The soil should be brought to a high state of fertility and maintained in this condition. In this manner the plant is able to obtain a continuous supply of nutrient material which will fluctuate according to its needs—suitable conditions for rapid growth being those which are suitable for rapid conversion of the organic material in the soil. This richness in organic matter is also very beneficial in retaining moisture in the soil, a plentiful supply of which is necessary for the successful growth of this crop. The organic matter is further of great importance in maintaining a good soil texture, which is very apt to be somewhat spoiled during the operations of washing and sulphuring when the soil is wet.

The manures applied annually per acre should contain a total of about 350 lb. nitrogen (= 425 lb. ammonia), 500 lb. calcium phosphate, and 200 lb. potash (K_2O). A typical scheme of manuring is 20 tons farmyard manure carted on and ploughed in during winter, followed by 8 cwt. superphosphate and 1½ cwt. sulphate or muriate of potash in February or March, and in May 10 cwt. fish or meat meal. If the bine is backward or the leaves yellowish during May or June, 1½ to 2 cwt. of nitrate of soda, nitrate of lime, or sulphate of ammonia will stimulate the plants. The manures are evenly distributed over the ground, for, after the first two years, the hop roots will cover the whole area of the garden.

Hop-growers at the present time usually find it impossible to get sufficient dung to enable them to make an application every year; to get over this difficulty dung is used in alternate years, 2 to 4 tons of shoddy, ploughed in during autumn, being substituted in the years when dung is not available. An extra 3 or 4 cwt. of sulphate of potash and ½ ton of superphosphate is added when shoddy is used, as this substance contains no potash or phosphate.

The actual manures employed may be widely varied; steamed bone

flour, bone meal, basic slag, guano, rape-dust, and fur waste are popular with growers.

Great care is required in the use of nitrogenous manures; the plant needs a plentiful supply, but over-manuring with this element is disastrous. Abundant growth of foliage and stem is produced which becomes matted together, excluding light and air; this favours the spread of mould and at the same time hinders development and delays ripening of the crop.

Potash manures are essential for the health and vigour of the plant, but if used in excess will also delay ripening. Potash is usually deficient in the lighter types of hop land.

Phosphatic manures, on the other hand, should be used liberally, particularly on the heavier types of soil. They tend to promote early ripening.

The hop, like most other plants, cannot tolerate acid conditions in the soil; this condition will arise through continued heavy manuring unless the soil is well supplied with lime. It is therefore necessary, on most soils, to give a dressing of 1 ton of quicklime during the winter every five years. This is best put on after ploughing as it tends to work downward in the soil.

Picking.

Hops are usually ready for picking during the first week of September in Kent; in Worcester and Hereford picking generally commences a few days later.

When ripe the cones close up, becoming yellowish in colour and crisp in texture. The small round fruits at the bases of the bracteoles become firm and their colour changes to a purplish brown. The lupulin when ripe loses its transparency and assumes a lemon yellow colour. If the hops are picked before maturity, not only is the crop smaller but the quality is also inferior to that of the fully ripe cones. On the other hand they should not be allowed to hang too long after ripening, or the bracts will open and some of the lupulin will be lost during picking and drying. Very frequently growers cultivate only one or two varieties, and consequently it is often impossible to get all the hops picked when in their best condition. Careful judgment is therefore necessary in deciding the date for the commencement of picking. The crop must be estimated as nearly as possible, and from this the probable duration of picking, by dividing the crop by the amount which can be dried per day—the drying capacity is generally the factor which limits the rate of picking. The date when picking shall commence is then settled so that the greater part of the hops will be in their best condition. It will be readily seen that in years when large crops are grown, many hops will be harvested in an unripe condition, to the loss of both grower and brewer. Picking often has to be started earlier than the grower would

desire, owing to the presence of aphides or mould in the hops, both of which spread rapidly and would completely spoil the crop, and for which no remedial measures can be taken at this stage.

Extra labour is always required for picking, and thousands of men, women, and children come to the hop-gardens every year from London and other large towns for this purpose.

With hops trained in the old-fashioned way, on poles, the bine must be cut, and the pole, with its load of hops, pulled from the ground before the cones can be picked. This is one of the disadvantages of training in this manner. At picking-time the leaves are still green and manufacturing food, and the plant is full of sap, which, when the whole plant ripens normally, is transferred to the root-stock for use by the plant in the following year. It has been shown by experiments carried out at Wye College that about half of the nitrogen and phosphates and over three-quarters of the potash in the bine when the crop is picked, travel down to the root on ripening. If the bine is cut this is lost, causing a marked diminution in crop in the succeeding season. In the case of wire-work the strings bearing the bines are pulled down from the overhead wires, and the bines are not cut until they have ripened off in November.

In East Kent the hops are picked into large basket measures holding 5 or 6 bus., each bushel being marked on the side of the basket. In other parts of Kent and in Worcestershire and Herefordshire they are picked into bins of loose-woven sacking supported on light wooden frames about 10 ft. long and 2½ to 3 ft. wide. The pickers are divided into sets or companies of 6 to 10 bins, or 12 to 20 baskets, each in charge of a " bin-man " who pulls down the bines and is responsible for the work of the pickers. He has to see that the hops are cleanly picked, without leaves or bunches, and that the hops are not scattered on the ground.

The baskets, when full, are emptied into a " poke " or " green bag " made of loose sacking and holding 10 bus., or 12 bus. where the 6-bus. baskets are used. Where the hops are picked into bins they are measured from these into the poke with a bushel basket, the measurer visiting each bin four or five times during the day. A " booker " is employed to keep account of the hops taken from each bin; it is also his duty to take note of the total amount of hops picked during the day, and to stop the picking when sufficient hops have been obtained to supply each oast with its day and night loads.

The average crop in this country is about 10·5 cwt. per acre, but it varies with different varieties and seasons from 6 or 7 to 30 cwt. per acre.

Drying.

The green hops contain about 80 per cent of water and will rapidly ferment and become spoiled if they are allowed to remain in this state; they are therefore dried as soon as possible after they have been picked.

The process is carried out in specially constructed kilns attached to a two-storied building, the whole being called a hop " oast ".

The most common type of kiln (fig. 11) consists of a square or circular brick building of 16 to 18 ft. side or diameter and 16 to 20 ft. in height, with a tapering tiled roof 10 to 14 ft. high. The inside of the roof is sealed with lath and plaster. A circular opening $2\frac{1}{2}$ to $3\frac{1}{2}$ ft. diameter is provided at the apex of the roof and over this opening a wooden cowl is pivoted, the bearings of which must be well oiled every year, as it is essential that it shall turn freely with the wind. On the ground-floor of the kiln is a brick fire-place situated near the door communicating with the lower floor of the oast-house. Radiant heat will injure the hops; an iron baffle plate is therefore often suspended over the fire to prevent direct radiation from reaching them.

Around the base of the kiln, at ground-level, four or five openings are made, fitted with sliding shutters to serve as ventilators when required.

There are numerous methods for regulating the rate at which the fire burns, and consequently the temperature of the air passing through the hops. This control is most important. A very efficient and simple method of heat regulation is by means of a vertically sliding iron door about half the height of the doorway leading to the fire; this door runs in grooves on either side of the doorway and is counterpoised by a weight on a cord which passes over two pulleys to the top of the door. If the door is raised the air passes under it and through the fire, causing the

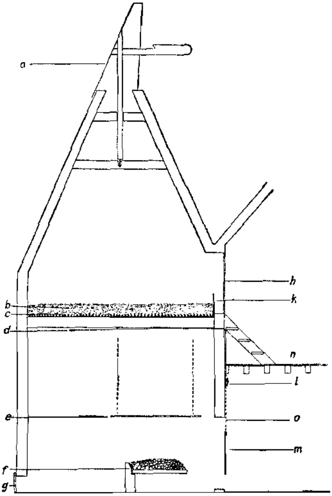


Fig. 11.—Diagram of Hop-drying Kiln

a, Cowl; *b*, Hops; *c*, Horsehair cloth (" hair "); *d*, Thermometer bulb; *e*, Iron baffle plate; *f*, Fire; *g*, Ventilator; *h*, Door to cooling room; *k*, Wooden slide; *l*, Pulley for counterpoise chain; *m*, Iron sliding door; *n*, Cooling room; *o*, Chain attached to counterpoise.

latter to burn brightly and raising the air to a high temperature. When the door is lowered to the floor the air passes over it and not through the fire, which dies down and the temperature of the air current is considerably lowered. With the door in intermediate positions it is possible to obtain a wide range of temperatures.

Above the fire (13 to 14 ft.) the floor is fixed on which the hops are dried. This consists of a number of laths, about 1½ in. wide, tapering to about ¾ in. at their upper edge, which are nailed 1 to 1½ in. apart on joists. Over these laths a loosely woven coarse horsehair cloth is stretched —horsehair is used to reduce fire risk. This floor is generally 3 or 4 ft. above the level of the upper (cooling) floor of the oast, to which access is given by a door and short ladder.

The hops are dried by the action of the hot air upon them; the heat hastens the vaporization of the water from the hops, the vapour being absorbed and carried away by the air current. In the type of kiln described above, the air current or draught is produced by natural means, in the same way as in a chimney. The air on being heated expands, therefore becomes lighter and rises, cold air flowing in to take its place. The speed of the air current will depend, in the first place, on the difference between the temperatures of the outside air and that within the kiln, being most rapid in cold weather and slower during hot periods. The height of the kiln will also influence the strength of the draught; the higher the kiln the more rapid will be the flow of air. The strength and direction of the wind also exerts a great influence on the draught; the wind tends to reduce the pressure within the cowl—which always turns back to the wind—thus drawing up the air from within the kiln. If, in addition to this, the wind blows toward openings in the lower part of the kiln the effect is increased. When the strength of the wind is insufficient to turn the cowl this must be done by the drier, by means of a long piece of string attached to the arm of the cowl and reaching to the ground; otherwise the wind may change its direction and cause a back-draught which will spoil the hops.

In this type of kiln the products of combustion from the open fire pass through the hops with the heated air; it is therefore essential that a smokeless fuel free from volatile injurious substances be used. Charcoal and best quality anthracite are employed for the purpose; the latter should be free from arsenic.

In many modern kilns a forced draught is produced by means of a rotary fan. This may be employed either to drive the air through the kiln from below or to exhaust the air from the kiln. In the former case the fire must be enclosed; the products of combustion usually pass through a number of iron flue pipes in the lower part of the kiln and thence to a main chimney up which they pass without coming in contact with the hops. Any fuel may therefore be burned in these stoves. The air is heated by being driven over the hot flue pipes.

With an exhaust fan the fire may be either open or closed. Many of the common kilns described above have been converted to forced draught by simply closing the opening below the cowl and fixing an exhaust fan in the side of the roof. Electric power, if available, is most suitable for this type of fan. Exhaust fans tend to reduce the pressure within the kiln, which is an additional aid to evaporation.

A thermometer should be fitted in each kiln, and several types are made specially for this purpose. A transmitting thermometer with a long flexible stem is a good kind; the dial on which the temperature is registered can be fixed in any convenient position. Another type which is largely used is a mercurial thermometer with a platinum wire fused through the bulb, and three similar wires through positions on the stem corresponding to temperatures of 135°, 145°, and 150° F.; these are connected with wires to a switch and electric bell. On reaching each of the above temperatures the mercury completes the circuit between the platinum wire in the bulb and that in the stem. The bell can therefore be made to ring by placing the switch on the button corresponding to the temperature which has been attained. In any case the thermometer bulb should be placed just below the drying floor, in a position not directly over the fire.

If kilns depending on natural draught are cold, they should be thoroughly warmed before they are loaded with hops, otherwise it will be difficult to maintain an efficient draught at the outset owing to cooling of the air by the walls of the kiln. This is a point of great practical importance; a weak air current at the commencement of drying is very liable to cause "reeked" hops.

The hops on arrival from the garden are very carefully spread evenly and lightly over the drying floor to a depth of 9 to 14 in., in the case of natural draught kilns. The depth is gradually increased as the hops ripen, the shallower loading being employed at the commencement of picking when they are green. With a forced draught a considerably greater depth can be dried at each loading.

If kilns are not available to receive the hops—as will usually be the case with those picked in the afternoon—the pokes are laid, in a single layer, on a staging of hurdles supported on short poles at a height of about 3 ft. This provides a free circulation of air and retards heating, which would spoil the hops.

The temperature of the kiln should be about 100° F. when the hops are loaded, the fire having been lighted and made up with large lumps of coal so that it will burn steadily for about three hours without replenishing. Making up the fire causes a temporary fall in temperature which would be detrimental to the hops in the initial stages of drying.

Soon after the hops have been levelled in the kiln, sulphur is burned in an iron pan beside the fire. This bleaches the hops to a certain extent

and gives them an attractive appearance, it is also said to lessen deterioration of the hops during storage. Statements have been made from time to time that burning sulphur hastens drying; recent experiments,[1] however, have shown this not to be the case. The amount of sulphur used will depend upon the strength of the air current. In ordinary open-fire kilns with natural draught 1 lb. of sulphur—roll brimstone—to 30 or 40 sq. ft. of drying floor is generally used. With a forced draught the volume of air is increased and it is necessary to burn a correspondingly larger quantity to obtain the same effect. The sulphur must be guaranteed by the vendors to be free from arsenic. It should never be thrown on to the fire but always burned in a separate pan; if placed on the fire the risk of contamination of the hops with arsenic is increased.[2]

The first three hours of drying is the most critical period. The hops acquire a dull appearance and are said to be reeked if the temperature is allowed to rise too rapidly or if the air current is checked during this time. The temperature should rise very gradually, so that 140° F. is reached in not less than three hours. This temperature should be kept fairly constant for the next three or four hours and may be maintained till the hops are dried, but it is generally necessary to allow it to rise somewhat higher during the latter stages of drying—when the hops are less liable to injury—in order that they may be dried in ten or eleven hours and so permit the drying of two loads per day. It is inadvisable, however, even during the latter stages to allow the temperature to rise above 160° F. or the market value may be considerably diminished. A rough test of temperature, used by driers before the introduction of thermometers, was to place the back of the hand on the horsehair cloth; if it could be held there fairly comfortably the temperature was considered not too high for the latter part of the drying. Experiments, carried out in connection with the research scheme of the Institute of Brewing,[3] have shown that the market value of the hops, as estimated at the present time, decreases as the maximum temperature of drying is increased.

If the hops appear to be drying unevenly in the later stages, owing to bad loading, they should be carefully turned to loosen the tightly packed places where the hot air is not passing through readily.

The hops are dried sufficiently when nearly all the strigs (axes) are brittle; a double handful rubbed between the hands should crumble to powder, leaving only five or six tough strigs. At this stage they will contain about 5 per cent of moisture. The fire is damped down and all the ventilators below the drying floor are opened. The dried hops are allowed to remain as long as possible on the hair before removal to the

[1] A. H. Burgess, "Report on Second Season's Work at Experimental Oast, 1922", Inst. Brewing Research Scheme, *Jour. Inst. Brewing*, 1923, p. 403.
[2] J. L. Baker and W. D. Dick, *Jour. Soc. Chem. Ind.*, 1904, 23, 174.
[3] A. H. Burgess, loc. cit.

cooling floor, so that the bracts may absorb a certain amount of moisture and thus become toughened. The hops are then shovelled off the hair by means of a large shovel-shaped scoop made of canvas on a wooden frame, the few that remain being swept out with a birch broom.

Special care must be taken not to break the hops after they have been dried, or much lupulin is shaken out and lost from broken cones and the market value lowered. For this reason devices for removing the hops from the hair without handling, e.g. the Hetherington patent roller floor, are frequently employed.

While cooling, the moisture content becomes more evenly distributed throughout the mass and a certain amount is absorbed from the atmosphere; this makes the hops less brittle and less liable to damage during packing.

Packing.

When packed, the hops should contain 8 or 9 per cent of moisture, and this will usually rise in a few months to 10 or 12 per cent during ordinary storage. Care must be taken that they do not absorb too much moisture before packing, otherwise they are liable to ferment in store and will be classified on the market as "cold packed".

English hops are packed in "pockets". These are stout bags 6 ft. long and 2 ft. diameter when packed. They contain 1½ cwt. of dried hops. A handful of hops is tied in each of the lower corners to serve as grips for handling the full pocket. The pocket is then suspended through a hole in the cooling-room floor, by means of an iron ring over which the upper edge of the pocket is turned. Hops are shovelled into the pocket with the scoop and pressed down with a mechanical press. (The old-fashioned method was to tread the hops into the pocket.) The press consists of a circular wooden foot, mounted, over the hole in the floor, on a long rack, which is worked by a pinion, geared down from a hand wheel. Great pressure can thus be exerted on the hops in the pocket, which must be supported below with a stout piece of webbing to prevent its being torn. The process of filling and pressing is continued until the pocket is full; it is then raised slightly by winding up the webbing and the mouth securely sown up with coping string.

If some hops, insufficient to fill a pocket, remain from a kiln load, they should be carefully covered up to prevent the absorption of too much moisture; these are well mixed with the next lot to be packed. The hops in each pocket must be uniform throughout.

Pockets are numbered consecutively and must also be marked with the grower's name, parish, district, and the year of production.

A sample is drawn from each pocket either by the grower or by the hop factor. The seam of the pocket is opened and two parallel longitudinal cuts are made through the hops about 5 in. apart. A specially

constructed pair of tongs is then thrust into the hops between the cuts, and the lump of pressed hops drawn out. The ragged end is trimmed off and the neat rectangular block (approximately 4 in. × 5 in. × 6 in.) wrapped in thick brown paper and numbered.

Marketing.

The hop grower sends his produce to a hop factor, who sells on commission to a hop merchant. The hop merchants supply the brewers.

Uses.

Hops are used for the preservation and flavouring of beer; they also assist its clarification.

They contain, in addition to the compounds usually met with in plant products, an essential oil, which gives the hops their aroma and flavours the beer, and three kinds of resins, two soft and the third hard. The preservative effect of the hops is closely associated with the amount of soft resins they contain, and their content of this is a useful guide to their brewing value in this respect.

The proportion of hops used varies, with different types of beer, from 1 lb. to 5 lb. per barrel.

A very small quantity of hops is also used for medicinal purposes.

DISEASES OF HOPS

By E. S. SALMON, F.L.S.

The most widespread and destructive fungous disease of the hop is that called by the hop grower " mould " or " red mould ". It is due to the attacks of a minute fungus, *Sphærotheca Humuli* (D. C.), Burr., a member of the " powdery mildews " (*Erysiphaceæ*). The hop grower of twenty or thirty years ago was in total ignorance of the cause of this disease, and attributed it to certain atmospheric causes, to the nature of the soil, or to errors of cultivation or manuring. At the present day, whilst most growers know the true cause of hop mould, viz. that it is a minute, parasitic fungus, there are still many who are unaware that red mould is nothing more than the same fungus; and there are still more, who, being ignorant of the life-history of the fungus, take spurious measures for its control while neglecting to take the right ones. Hop mould, if neglected, will increase to such an intensity that complete ruin of the crop results, and many a case of financial disaster in hop farming may be traced to the neglect of taking precautionary measures against hop mould. Whilst the use of sulphur against mould is practically universal amongst growers, it is not yet generally understood how vitally important it is that applications of sulphur should be given early in the season. Full details of the necessary measures to be taken for the control of mould are given below.

Life-history of the Hop Mould.

The fungus is visible to the naked eye, on the hop leaf, as a white, powdery patch or spot. With a pocket magnifying glass, or under the microscope, it can be seen that the fungus is composed of white, interlaced, branched threads (*mycelium*), creeping over the surface of the leaf, and numerous slender upright branches (*conidiophores*), each bearing a necklace-like chain of summer spores (*conidia*). The threads of the spawn, or mycelium, send at short intervals very numerous " suckers " (*haustoria*) into the hop leaf, and by this means the fungus extracts its

necessary food from the sap of the hop plant. As each spore becomes ripe, it separates from the chain and, being very minute and very light, may be carried on the wind, probably for many miles. Immense numbers of summer spores are produced; Professor Blodgett has computed that on a square inch of leaf surface covered with hop mould, 2,800,000 summer spores are produced. Each summer spore behaves like a seed, in that it gives rise to a new individual. On reaching a healthy leaf or a " hop ", the spore at once proceeds to infect it, by putting out a root-like germ tube, which fastens on to the surface of the leaf or hop, sends suckers into its tissues, and within a week or ten days a new patch of mould is produced, bearing a fresh crop of summer spores. Owing to this rapid method of propagation, any neglect by the hop grower to kill the first spots of mould that appear in the hop garden may be fraught with grave consequences. The white stage of hop mould, powdery with accumulated summer spores, may occur throughout the season on the young leaves, lateral shoots, runners, the burr, or young hop cones. The greatest damage is done when mould attacks the burr, i.e. the female inflorescence of the hop plant. Under the attacks of mould, the burr is transformed into distorted, white knobs, instead of developing into hops, as it does when healthy. The hop cone is liable to be attacked at all stages of growth.

The disease known as red mould is one of the commonest manifestations. Here the ripening hop cone shows patches of a foxy or reddish brown colour where the petals are attacked by the mildew, which in this case develops but little spawn and few summer spores. It was long thought that red mould was distinct from white mould, but it is now definitely established that red mould is nothing more nor less than white mould, and that one form can change into the other according to the part of the hop plant that is attacked. Red mould is one of the most insidious forms of the disease, and can only be dealt with by the rigorous suppression earlier in the season of all outbreaks of white mould.

The summer spores are quite unable to survive the winter months, when the hop plant dies to the ground, and during late summer the mildew enters into a new stage of development in which it passes the winter. This stage is far more difficult to see than the white mould. It can, however, readily be detected with a pocket lens. If during late summer the mould on the leaves or hops is examined, minute, round, blackish brown bodies, or conceptacles, can be observed, usually densely clustered on the spawn. Each conceptacle (*perithecium*) contains within it a minute sac (*ascus*) holding eight winter spores (*ascospores*). When the hop leaves decay, or when mould-affected hops are left unpicked and allowed to blow away, the conceptacles with the winter spores reach the soil of the hop garden and remain there in security through the winter

months. The following spring—usually in May—the winter spores are liberated by the conceptacles bursting open and ejecting the winter spores into the air. Some of these ascospores, wafted about by air currents, get carried to a hop leaf, usually the lower leaves on the bine. The winter spore infects the leaf, and in a few days a powdery patch of white mould is produced, bearing hundreds of summer spores. Thus is brought about the first or primary outbreak of mould for the season.

From the point of view of the practical farmer, the most important facts in the life-history of the hop mildew are: (1) The fungus is confined to the surface of the above-ground parts of the hop plant, never entering the hill or occurring on the roots. (2) During the summer months the mildew continues to produce, unless checked by sulphuring, millions of summer spores, which can spread the disease far and wide. (3) During the winter months the mildew exists only in the form of winter spores within closed conceptacles, which become dispersed over the surface of the soil of the hop garden. The following year, about May, the winter spores are liberated and produce at once the highly infectious white mould. No means are known of killing the conceptacles in the soil.

Preventive Measures. *Direct.* — As all hop growers know, "flowers of sulphur" (pure, sublimed sulphur) is the great specific against mould. In order to obtain the best results, the observance of two points is essential: (1) the flowers of sulphur must be of a brand guaranteed to be pure, and free from admixtures—such forms as "green" and "black" sulphur should be avoided; (2) it must be in a condition of very fine, dry, dust-like particles, free from lumps or "caked" masses. If the sulphur has become caked, it must be passed through as fine a sieve as possible.

Applications of sulphur should commence in May, when the hop bines are about 5 ft. high. One good early sulphuring frequently prevents a bad outbreak of mould later in the season, and should never be omitted. In hop gardens where mould has occurred during the previous season, further applications of sulphur should be given regularly at intervals of a fortnight until the bines are high enough for the horse-sulphurator to be used. Up to the time the burr appears, any white mould in the garden should be promptly dealt with by repeated sulphurings. It is the practice of many of the most successful hop growers to sulphur the hops when in burr, not only as a preventive of mould, but in the belief that the sulphur acts in some beneficial way, causing the burr to set into hops quickly. Generally speaking, no further sulphuring is necessary; should, however, red mould appear, applications of sulphur must be given until the hops are approaching ripeness. Every effort should be made to avoid the necessity for putting sulphur on nearly ripe hops, since the presence of this between the petals of the cones in samples of dried hops on the market is a legitimate reason for their

rejection by the brewer or his agents, as the sulphur acts deleteriously in the processes of brewing. If the white mould is combated up to the time the hops are in burr, and during that period, there will be little likelihood of any outbreaks of red mould.

In wet weather it is difficult to keep down attacks of mould by the use of flowers of sulphur, probably because of the removal of the latter by the rain. A solution of "liver of sulphur" (*potassium polysulphides*) at the rate of 2 lb. to 100 gall. water, with the addition of soft soap, is probably the most useful wash under the circumstances. A new form of sulphur, viz. colloidal sulphur, used with water, is now being put on the market and will probably prove useful.

Indirect methods. Destruction of mouldy hops and bines.—Mould-infested hops are sometimes left on the poles or wire-work for weeks after hop-picking time for the linnets to shatter or for the wind to blow away. The result is that the petals of these over-ripe hops, bearing thousands of conceptacles with their winter spores, become dispersed over the surface of the hop garden, so that next season, given suitable weather conditions, severe attacks of mould occur again in the same garden. Immediately after hop picking, and before the unpicked mouldy hops have become shattered, the bine and the mouldy hops should be collected and burnt on the spot or carted off to make a bonfire on ground outside the hop garden. Infected bines and hops should not be used as litter in yards where the dung is carted out to hop gardens, nor as foundation for stacks except in places far removed from hop gardens.

Early "stripping" and removal of "runners".—It is a wise precaution, in addition to early sulphuring, to strip off the lowermost leaves of the bine as early as it is safe to do so. All runners that grow out of the hill during the summer should be "pulled" or cut off with the hoe.

Avoidance of "housing-in".—With certain systems of planting and training, there is a tendency for too much bine to be produced, which gets matted together in "heads" extending across the alleys—a condition known as "housed-in". This should be avoided.

Balanced manuring.—Excess of nitrogenous manure induces late sappy growth of the hop plant, which is then specially liable to be overrun by mould. The necessary phosphatic and potash requirements of the crop must not be neglected.

Provision of male hops.—The planting of male hops (one male hop to every 150 female hills) throughout the garden secures fertilization, and thus shortens the critical period when the hop is in burr.

Extirpation of wild hops.—All so-called "wild hops" in the vicinity of a hop garden should be grubbed up. Since mould frequently occurs on such wild hops, which of course are never sulphured, their existence is a real source of danger.

Varieties resistant to mould.—New seedling hops, immune to mould, have been raised at Wye College, Kent, and are now being tested, as regards their commercial value, at the Fruit and Hop Research Station, East Malling.

Spurious measures often taken against mould.—In the mistaken belief that mould lives in the hill during the winter months, hop growers sometimes apply chemical substances such as sulphur (yellow, black, or green), gypsum, or some proprietary compound, to the crown of the hill in early spring. This practice is a mere waste of labour and material.

Hop "Canker" or "Growing-off".

This disease is far less generally distributed than hop mould, but where outbreaks occur serious damage may be done season after season, as the attack is likely to remain persistent unless the right measures are taken to counteract it.

Above ground the presence of the disease is indicated by the withering or wilting of one or more bines at each affected hill; such bines will be found to be almost severed at the base and easily come away from the root-stock with a slight pull, a condition which is sometimes described by growers as "growing-off" of the bines. This wilting of the bines is accompanied by a canker of the underground root-stock, the infected portions being brown and dead.

The basal parts of diseased bines which have been dead for some time often bear white pustules of the fungus *Fusarium*, which is the cause of this disease. Bines just beginning to wilt do not usually show these pustules, but usually the bark and even the wood is brown, and the spawn (*mycelium*) of the fungus is found invading the brown tissues. If the bines become infected but are not killed until late in the season, their bases become abnormally thickened, due probably to the accumulation of foodstuffs travelling downwards from the leaves and unable to reach the root-stock because of the partial severance of the tissues at the junction of bine and rootstock. These swollen bases become invaded by the fungus, which produces pustules of *spores* at the surface.

Hop canker is a sufficiently serious disease to cause appreciable damage. As a rule only a certain number of the bines on any one hill die off, and the whole plant—the hill—is not generally killed. Cases have occurred, however, where from 5 to 10 per cent of the hills have been completely destroyed. Where the hops planted belong to a variety which is particularly susceptible to canker, i.e. the Rodmersham (or Mercer's) Golding, a certain number of dead hills is almost invariably to be found.

While by no means confined to hop gardens on heavy wet soils, the disease does appear to be favoured by moist conditions. The general experience of hop growers is that canker is worse in a wet season or following a wet winter. If there is a wet, clayey patch in a garden, the

hills are likely to be more severely attacked there than in the other parts of the garden, and that side of a garden which gets least sun will frequently show the greater number of diseased hills.

Preventive Measures. *Direct.*—(1). Hard cutting or dressing of all the hills in the affected part of the garden should be employed. All the browned part of the hill (root-stock) contiguous to the swollen or cankered bines should be pared away with a sharp knife. (2) All dead hills in the garden should be grubbed up and destroyed. (3) In the affected part of the hop garden all the cuttings from the hills should be collected and destroyed when they are cut, as the *Fusarium* fungus will develop pustules of spores on the swollen cut-off " straps ", and these may infect the cut surface of the plant in the hill.

Indirect Measures.—Drainage, or cultivation to remove the moisture from wet land, or letting in the sun, appears to have a favourable effect on keeping canker in check.

Virus Diseases of the Hop.

In 1895 a disease known locally in Sussex and Kent as " silly hill ", or " nettlehead ", was investigated by Percival, who attributed its cause to an eelworm (*Heterodera Schachtii*). In this disease the bines of the hop become stunted and barren, climbing only to about 5 ft.; the leaves take on an unusual shape, somewhat resembling those of a nettle (hence the name of nettlehead), have a mottled green and yellow appearance, and show an incurved margin. The disease spreads gradually, until considerable portions of the hop garden are rendered unproductive season after season, and the hills have to be grubbed up. The variety Fuggles is very subject to attack. Recent investigations have shown that the eelworm, which is frequently but not invariably to be found on the roots of affected plants, is not the cause of the disease, which, like the one described below, must now be considered to belong to the recently discovered group of " virus " diseases.

The second disease, known as the " mosaic disease ", is of more recent appearance, being first described in 1922. It is now widespread in Kent, Sussex, Worcestershire, and Hereford. This disease is characterized by the shortened joints of the bines, which usually refuse to climb, remain barren, and fall away from the strings when about 5 or 6 ft. from the ground; the leaves are recurved and, together with the upper part of the stem, become very brittle. In rare cases the tips of the bines, and also of the laterals, die back a certain distance. In most cases there is a characteristic mottled appearance of the leaf, which, instead of being uniformly green, is mottled green and yellow—hence the name mosaic disease. There is also frequently a tendency for the leaves to split along the veins. Hills affected with the mosaic disease never recover, and usually die after a few years.

Control Measures.—In the case of such virus diseases as the nettlehead and mosaic of the hop, just as in leaf-curl and mosaic of the potato, no direct remedies are known, and the only practical control measures consist of a careful system of rogueing the affected garden.

1. As soon as the disease is recognized the affected hill should be grubbed up at once. There is reason to believe that the green-fly (*Aphis*) spreads the disease from an infected plant to healthy ones.

2. When an affected hill is seen, the adjacent hills should be carefully scrutinized for the detection of the first signs of the disease, and all hills showing suspicious symptoms should be grubbed up at once. A systematic examination of the hop garden should be made during June and again just before hop picking.

3. No cuttings should be taken at all from a hop garden in which the disease occurs, or, if that is impracticable, then no cuttings should be taken from that part of the garden where the disease has occurred.

OSIERS AND WILLOWS

By HENRY P. HUTCHINSON

Osiers and willows have been used as basket-making materials from prehistoric times. Specimens of basket-ware made of willow have been obtained from ancient Egyptian tombs. The Greeks and Romans were well acquainted with the value of the crop, and bestowed considerable care upon its cultivation. Columella states that he regarded his willow crop as next in importance to his vineyard. It may be safely assumed that the methods of cultivation in this country have continued from Roman times—the varieties now grown being selections from wild sorts which were found to have properties best suited to the basket-makers' requirements. Willow rods continue to have an important value in industry as suitable material for the making of many forms of transit packages. This value lies in the fact that they secure in the manufactured article a combination of strength, durability, lightness, degree of elasticity, and low cost in production unequalled in the use of any other material.

No official returns are published in respect of the acreage of land in this country under willow crop. As an approximate estimate the acreage in the chief willow-growing centres may be accepted as follows:

Somerset (Parrott Basin) ..	3000 ac.
Thames Basin	1000 „
Trent Basin	800 „
Severn Basin	600 „
Cambridge area	1000 „
Lancashire (Ormskirk area) ..	400 „

Willow beds, holts, or garths are cultivated in most river valleys throughout the country and the crop is frequently grown on sewage farms, but it is not possible with any degree of accuracy to compute what the total of such acreage is. It was noted by Scaling about 1870 that in spite of the existence of suitable soil and climate, not more than 120 ac.

of basket willows were then grown in Scotland, and probably the area in the country at the present time does not exceed 200 ac. Basket-makers rely upon England and the Continent for their supplies of rods.

Classification.

The varieties of willows most extensively grown in this country belong to the following species.

1. *Salix viminalis*—Osiers proper. The species may be recognized by the great length of annual shoot and by the presence of long leaves covered with fine silky down on their under surfaces. The varieties such as Brown Merrins, Longskins, Mealy Top Osier, Green Osier, and Continentals are distinguishable amongst themselves by such characters as colour of bark in winter, times of flowering, and quality of rods, but all the varieties are similar in the heavy crops and individual size of rods which they are capable of producing. As " white " or " buff " the rods are valuable for the making of large-sized basketry, but as they contain much pith relative to wood the quality is frequently not good enough for the making of first-class quality articles. As " brown " the rods are used for the making of common baskets and hampers. The rods of all the varieties of the species relative to other species are less finely drawn out at their apices. For this reason they are frequently described in the basket-making trade as " full tops ".

2. *Salix triandra*.—The leaves of all the varieties of this species have serrated edges and are smooth on both surfaces. The rods are finely tapering at their tips, and are consequently known in the trade as " fine tops ". There are numerous varieties in cultivation, the chief being Black Maul, Germans, French, Glibskins, Champions, Long Bud, Stonerods, Whissenders, and several strains of Spaniards. The species includes the best basket willows in existence, which are characterized by their great length in proportion to thickness, their freedom from side shoots, and their ability to withstand with minimum break of tissue the complicated bends and twists of the basket-maker.

Good quality rods of this species are always in demand. They are used in the making of furniture, transit hampers, and in all cases where the best quality willows are required.

3. *Salix purpurea*.—The chief commercial varieties of this species produce short rods, generally not exceeding 4½ ft. in length. The characters of distinction are: smooth leaves with entire margins and absence of stipules, freedom from side shoots, fineness of the rods, and intense bitterness of all parts of the plant. The variety Dicky Meadows, or Red Buds, is grown exclusively in an extensive way at Mawdsley, in Lancashire, and its rods are used in the making of small basketry of the finest quality. Welch, Kecks, or Goldstones is a variety which attains an annual growth of rod of 6 or 7 ft. Small quantities of this variety are

grown in most willow-growing centres. Its value lies in the fact that it forms excellent tie rods for binding purposes.

The Golden Willow (*Salix vitellina*) and the Belgian Red Willow (*Salix cardinalis*) are grown in the Thames Basin and are distributed in small quantities throughout the country. Their greatest value is as tie rods in the market-garden industry.

A few hybrid varieties of willow are grown in several centres, but these cannot be regarded as possessing qualities superior to those of their parents.

Soil and Climatic Conditions.

Although willows will thrive and continue for many years to give good crops of excellent quality on land raised well above flood-level, in an economic scheme of cropping the proper position for the crop is on valley land, which is generally too wet to be grazed or is unreliable as meadow. On land at or near the water limits of cultivation there appears to be no crop which can approach the willow in the financial returns which it is capable of giving. Heavy river-valley loam overlying clay constitutes the best type of soil for the crop in respect to annual yield, quality of rods, and longevity of heads, which may extend to twenty-five years. Generally these characters diminish as the soil diminishes in clay content. In peat soils the heads may not live longer than five or six years. Deep and frequent flooding is not harmful and may be beneficial to the crop, provided the excess of water leaves the land freely with subsidence of the water in the neighbouring watercourses. No variety of willow will grow satisfactorily on land permanently waterlogged to its surface, but provided the water table can be kept at 18 in. or 24 in. below the land surface during the greater part of the annual growing period the crop will thrive. Winter floods do no damage, but may interfere with the cutting operations and removal of the rods.

The climate of the country suits the crop. Occasionally spring frosts kill or damage the first yearly shoots, hailstorms may damage the rods, and violent wind storms may loosen the stocks. The crop is subject to insect and fungus attacks which may do very considerable damage.

Management.

In the establishing of a willow holt it is essential to success that the drainage system should be adequate. The required conditions can generally be secured by the cleansing of adjacent watercourses and, if necessary, by the cutting of dykes or grips. The land surface should be cleared of encumbrances which, if allowed to remain, would obstruct cultivation operations. The old practice of preparing land for planting was to double dig with the spade, whereby the turf was buried, and but for the expense incurred in this method it is still the best which can be

employed, and can be carried out when it is impossible to get horses and implements on the land.

The system of deep ploughing is the method now used. Two main objects should be achieved, viz. (1) the inversion and complete burying of the turf, and (2) the taking a proper depth of furrow so as to leave ultimately about 12 in. of open soil into which the sets, 12 to 14 in. long, may be inserted almost to their full lengths. In practice it has been found that by double ploughing the operation is performed with least trouble and expense. When in proper going order the first plough, working at a depth of about 3 in., pares and turns the sod into the bottom of the furrow. The second plough, following at a depth of 8 or 10 in., lifts the under soil and turns it into the furrow, whereby the turf deposited by the first plough is completely buried.

The direction in which the land is ploughed should be such as would enable the open furrows to be used as outlet channels for flood water.

Planting may be done at any convenient time between November and March. The sets consist of 12- to 16-in. lengths cut from whole rods. After harrowing, these are inserted to their full lengths. The planting distances depend upon the variety of willow. When after-cultivation by horse-hoe is intended, the distances between the rows should be just wide enough to admit of the passage of a horse without causing injury to the plants. Generally 22 to 26 in. is allowed for this, and distances between neighbouring plants in the same row so arranged as to give from 15,000 to 22,000 plants per acre. The practice of "square planting", i.e. the maintaining of the same distances between rows and adjacent plants in the same row, is sometimes adopted with a view to enabling horse-hoeing to be done in two directions, but the advisability of planting on this system depends on the shape of the field. An objection to this method is that after a few years the distances become too narrow for a horse to be used without causing injury. The crop should be kept clear of weeds for the first three years after planting. Afterwards, although a clean land surface will produce heavier fields of rods and greater longevity of heads, it has been found good policy by some growers to permit grass to grow between the plants, whereby expense in cleaning is spared. The grass is kept in check by grazing with cattle for a few weeks before the willows make their first shoots and afterwards by cutting it with short hooks or sickles. By this means the young shoots get advantage in growth and later act as a smother crop for the grass below. Where land, owing to excessive wetness, cannot be prepared and planted as thus described, useful crops have been grown by clearing the land surface by means of the scythe and planting immediately by taking sets up to 3 ft. in length and inserting these, leaving 18 in. or 2 ft. out of the ground to form high-crowned plants.

Harvesting.

The crop may be cut at the end of the first growing season after leaf-fall, and annually onwards throughout the life of the heads. But it has been found advantageous at times to allow a crop to remain uncut for two or three years. By this means thicker rods are produced and the plants are invigorated for further annual crops.

The cut rods are tied in bundles of convenient size and may be "buffed" immediately. This operation consists in boiling the bundles in tanks having dimensions of about 12 ft. length by 3 ft. width by 4 ft. depth. The effect of boiling is to enable the bark to be easily removed and also to induce a red-brown colour in the wood.

The rods are afterwards dried in the open, sorted and graded in sizes, tied in bundles, and then stored in a dry place.

"White" rods are prepared by removing the bark when spring growth is commencing. When rods are peeled directly from the heads, the operation cannot be carried out, in the case of any single variety, for longer than two weeks on account of the new wood, which at once begins to be formed, not adhering sufficiently close to the wood of the previous year's growth. The difficulty is overcome by growing several varieties which attain their peeling conditions at different times, but chiefly by placing rods, cut during the winter, upright in dug-out oblong pits fed by a neighbouring stream. Under these conditions bark is removed when sap movements begin and may be continued until July. By this method the formation of new wood is largely prevented. After having been dried in the open the rods are graded, bundled, and stored. Rods which are not peeled are allowed to dry and may then be stacked and thatched. The material in this condition is known as "brown".

Yields and Returns.

The expenses incurred in planting land with willows vary considerably, and could only be computed with any degree of accuracy in the case of any given field. A prospective grower would be able to estimate his expenses by consideration of clearance, fencing, ditching, draining, planting, cultivation, cutting and carrying off crop, rent, rates, and interest on outlay. A fair total might be £35 an acre for the first year and £7 to £10 per acre for subsequent years.

For a crop of good quality rods—first year's growth after planting—a fair yield would be 2½ tons per acre, worth £4, 10*s*. per ton = £11, 5*s*.

Similarly for the second year a cost of £8 per acre would be met by a yield of 3½ tons at £4, 10*s*. per ton = £15, 15*s*., and for the third year expenses would be £8 per acre and returns 5 tons at £4, 10*s*. per ton = £22, 10*s*.

Thus it takes three years to cover the cost of planting, which is the

ordinary calculation of growers. Afterwards yields of 6 to 8 tons per acre may be expected for the following 12 or 15 years, after which the yields would decline.

The grower should be in a position to convert his green crop to peeled rods, either white or buff. The loss in weight incurred by the process is about two-thirds the weight of the green crop. Thus 6 tons green = 2 tons peeled rods. The latter at the present time would be worth £25 to £30 per ton. The labour expense in producing 1 ton of peeled willows would be from £7 to £10 per ton, so that a fair profit is possible on the process.

	£	s.	
3 tons green willow at £4, 10s. =	13	10	producing 1 ton peeled willows worth £25 to £30.
Peeling .. .. .. =	8	0	
Total cost	21	10	

THE TOBACCO CROP

By JOSEPH HANLY, F.R.C.Sc.I.

The tobacco plant is a native of America. It belongs to the same natural order (Solanaceæ) as the potato, which also came to us from that country. Over forty species of tobacco have been described, but of these only three are of commercial importance. From these three species have been developed a very large number of varieties.

The commercial classification of tobacco, which is of greatest importance, is based of course on the different requirements of the trade.

The tobacco plant is believed to have been brought to Europe from America by the Spaniards soon after the discovery of that land in 1492. In 1560 it spread from Spain to Portugal and was conveyed to England by Sir Francis Drake and others about the same time. During the period 1570–84 Sir Walter Raleigh succeeded in popularizing tobacco smoking in England.

The tobacco plant was probably introduced into Scotland and also into Ireland early in the sixteenth century, and was valued at first for medicinal purposes. During the latter half of the sixteenth century the cultivation of tobacco both in Great Britain and in Ireland became very general and extensive, the soil and climate of both countries proving highly favourable for its growth.

Queen Elizabeth imposed the first tax—2*d.* per pound—on tobacco, but James I, who strongly disliked the weed, increased the tax in 1603 to 6*s.* 10*d.* per pound. The Puritans considered tobacco smoking profane, asserting that its fumes " savoured of the devil and hell ", while Cromwell believed that the growth of tobacco was to " misuse and misemploy the soil ". So strong were his convictions on this point that he sent his troopers to trample down the crops. In spite of this opposition smoking continued and increased while smuggling in various forms became rampant. After many vicissitudes the cultivation of the plant, both in England and in Ireland, was entirely prohibited by King Charles in 1630. From that period until 1780 the home cultivation of tobacco was continually being revived by the people and checked again by suc-

cessive Parliaments in favour of its growth by the American colonies. By a special Act of George III in 1780 tobacco growing in Ireland was allowed, but its cultivation in England and Scotland was still prohibited. In 1831 King William IV finally prohibited its cultivation in Ireland. From then until towards the close of the nineteenth century the growth of tobacco in these countries was negligible. In 1886 the Government permitted an approved number of persons to cultivate tobacco in the United Kingdom, for experimental purposes, since which period its cultivation at home has received increasing attention. The experience gained by many recent experiments justifies the hope of an extended industry in tobacco growing in the future, provided its cultivation is not to be unduly hampered by excise restrictions. The question is now not whether tobacco can be grown in these countries, but whether it can be grown continuously with profit.

Experiments carried out at the Agricultural College, Wye, and at other centres on the growing of tobacco for nicotine extraction have proved decidedly encouraging. The Wye experiments show that from an average yield per statute acre of 1770 lb. of dried leaves about 114 lb. of nicotine could be obtained. Under average conditions of cost and marketing this return would prove substantially remunerative.

The British Tobacco Growers' Society was established in 1913 for the revival of tobacco growing in Great Britain. This society was formed with the approval of the Development Commissioners as part of a large scheme for agricultural development. It has since its inception conducted many experiments and investigations that are of much economic value. From 12 to over 80 ac. of tobacco have been grown each year since 1913, particularly in Norfolk where the soil was found to be most satisfactory. The crop has been grown successfully, however, in many other parts of the country, including Wales and Scotland. The Scottish experiments were conducted in Kirkcudbrightshire, on loamy soil. The actual results were satisfactory, except that the crop was somewhat late in ripening on account of the damper climate. The extensive system of dairy farming in the districts in which the crop was grown, however, militated strongly against the economic production of the tobacco. The average yield of tobacco, for six seasons, in Great Britain (dried to 25 per cent of moisture) was 1013 lb. Heavy smoking, cigarette, and cigar types have been grown. In latter years the lighter types have given the most satisfactory results. The estimated average post-war cost of growing an acre of tobacco is:

	£	s.	d.
Materials	6	0	0
Labour	16	0	0
Establishment charges	3	0	0
	25	0	0

or approximately *6d.* per pound of cured tobacco. Under satisfactory economic and business conditions this return would afford a reasonable profit to the grower.

Experiments on tobacco growing have been carried on continually in Ireland since 1900. In fact during that period the crop has received more attention in Ireland than elsewhere in the kingdom. These experiments have proved beyond doubt, if indeed proof were required, that tobacco of a high quality can be grown commercially in Ireland. One of the most vigorous varieties, *Nicotina rustica*, which is now grown commercially on a small scale, and which may ultimately be grown extensively for the production of nicotine—of which it contains a high percentage—is a direct survival from Wexford, where it hung on from year to year since the destruction of the industry nearly ninety years ago. A species of tobacco grows wild in parts of Ireland, which in itself indicates its acclimatized suitability for these countries.

Soil, Manuring, and Climatic Influences.

The tobacco crop has been grown successfully on a great variety of soils ranging from strong clay loams to sandy soil and bog. Generally speaking all these types of soil have produced a fairly uniform result. Light soils, however, provided they are deep and dry, appear to produce the best quality of leaf, and bog land the coarsest. Stiff, heavy, damp soils are not well suited for tobacco growing. After numerous experiments in different parts of Great Britain the British Tobacco Growers' Society prefers the county of Norfolk, where the soil is light and sandy.

For the production of quick growth and full and early maturity the soil requires to be deeply tilled and well manured. The quality of tobacco is considerably influenced by manuring, and, under average conditions, a dressing of dung from 25 to 35 tons per statute acre—that is, in proportion to the inherent richness of the soil—together with from 5 to 10 cwt. of a complete mixture of artificial manure in a fairly soluble form, generally gives the most satisfactory returns, unless, perhaps, in the case of some Turkish, Virginian, and other types that do not require heavy manuring in these countries.

Farmyard manure alone tends to result in slow growth and late ripening. When sown on good ground after a manured crop tobacco is sometimes grown successfully on from 10 to 12 cwt. of a complete mixture of artificials alone, but as a general rule a combination of farmyard and artificial manures is best. The different ingredients of artificial manure appear to act on tobacco in very much the same way as they do on other plants; that is, excessive nitrogen tends to produce a heavy, coarse leaf, phosphates encourage early ripening, while potash improves the smoking properties of the leaf. It has been estimated that a 2½-ton

crop of tobacco, weighed in a green state, takes from the soil about 89 lb. of nitrogen, 27 lb. of phospboric acid, 143 lb. of potash, and 108 lb. of lime per statute acre. It will be seen, therefore, that the crop requires a relatively large amount of potash, and sulphate of potash is probably the best form of artificial manure to supply this ingredient. The British Tobacco Growers' Society recommends that neither kainit nor potassium chloride should be used, because it asserts that these manures affect unfavourably the burning quality of the tobacco.

Excellent results have been obtained from about 6 cwt. per acre of the following mixture along with a medium dressing of farm manure:

1½ parts nitrate of soda,
3 parts potassium sulphate,
4 parts superphosphate.

If the soil is fairly free from grubs, such as wireworm, leather-jacket, or slugs, which are very destructive to the tobacco crop, it can be grown after any crop, or may succeed itself repeatedly if the soil is kept clean and suitably manured. In fact where these conditions are observed the crop may even improve on repetition on the same soil, both in quality and yield. It does well after corn, or may take the place of a root crop; it is also suitable for planting after an autumn-sown green crop that has been used during spring. Where tobacco is grown on the same soil successively, green manuring may be successfully utilized for replenishing the supply of vegetable matter in the soil, and thus reduce the quantity of farmyard manure required.

Seeding.

The seed of the tobacco plant is very small—1 oz. contains about 300,000 seeds—so that the reserve of food material for the nourishment of the young plant is soon exhausted. On this account it must be sown with great care in a well prepared seed-bed. The seed is usually started in a sheltered hot-bed or indoors. A plain, portable, glass-covered frame over a bed heated with stable manure is very simple and is quite satisfactory. The making and management of the seed-bed is of the utmost importance to the after success of the crop. Up to the present, largely owing to want of experience, seed-beds have not, as a rule, received the attention they require.

The seed is sown under an exceedingly light covering of soil from the middle of March to the middle of April. The young plants will usually be fit for planting out in about six to eight weeks afterwards. As soon as the plants have covered the ground, if they appear to be too thick they should be thinned, allowing each plant in the frame about 1 sq. in. of space. If they are very thick or if the plants are growing spindly a second thinning may be required.

Planting Out and After-treatment.

The young plants require to be hardened off by gradual exposure before planting out; if this is done they will stand light frost without damage after being transplanted in the open. It is safest, nevertheless, not to plant out before the middle of May, or until such time as danger of heavy frost in the particular district is over. While very small plants may be planted out, strong ones are to be recommended for preference.

The distance to be allowed between the plants will depend largely on the variety and on the soil. On good soil, the rows, whether they are in drills or on the flat, should be about 3 ft. apart. The plants should be firmly dibbled in at from 1¾ to 2½ ft. asunder in the rows. Pipe and cigar varieties are usually given good room, as it is desirable to aim at the production of large leaves. No definite rule can be laid down for either the width of the rows or the spacing in the rows, so much depends on local requirements, soil, and variety.

The following table shows the number of plants required per acre at various distances:

3½ ft.	by 2½ ft.:	6000 plants	per statute	acre.
3 ,,	2 ,,	7260	,,	,,
2¾ ,,	1¾ ,,	9075	,,	,,

The crop is usually grown in shallow drills and should be kept quite free from weeds. In the case of tall-growing varieties moulding up the drills during summer is advisable.

One of the most important considerations in the cultivation of tobacco is shelter, especially from wind. A promising but unprotected crop may be utterly destroyed by wind in a few hours, especially in the latter part of the season. Thick hedges, suitable shelter belts, the growing of hemp, beans, artichokes, or sunflower around the crop, and the growing of the tobacco in small, well-sheltered fields, are some of many devices that are adopted to protect it against wind. Experiments have been tried with artificial erections; they have, however, proved very costly as a rule, and in latter years have been practically abandoned.

The tobacco plant is generally inclined to run to seed, and for this reason the crop is topped during summer. Topping means that the flowering head, together with all the leaves that are not likely to develop fully and ripen, are pinched out and removed. From 7 or 8 to 20 leaves may be left according to the variety and requirements. The best time for topping varies with different varieties and with other conditions, but normally it is done after the first flower has shown. Most Turkish and some other varieties are not topped.

After the crop is topped, or even sometimes before, a number of lateral shoots or suckers spring from the axils of the leaves. If these

are not removed by pinching out, all through the season, they will very seriously depreciate the value of the crop. This operation, as well as topping, hastens ripening, swells the remaining leaves, and improves the quality of the crop.

Indications of Ripening—Harvesting.

Ripeness of the tobacco crop is indicated by the drooping of the leaves, increase of body, and by their changing in colour and becoming brittle, especially at the tips; the edges of the leaves curl while the surface loses its glossy smoothness and assumes a grained appearance. It is of great importance that the crop should be harvested at the proper period of ripening. Particularly during a wet season, or in late districts, ripening is often very protracted, more particularly in the case of heavy black tobacco. During the ripening period various substances which bestow quality on the tobacco, accumulate both inside and on the surface of the leaves, and at no time during the season is bright, dry weather more serviceable than at this period. Much dampness, especially soft, warm rain, shortly before the plants are ripe, may seriously injure the smoking qualities of the resulting leaf.

The lower leaves of the tobacco crop ripen earlier than the top ones, and because of this, two systems of harvesting are adopted. In one case the individual leaves are taken off as they become sufficiently ripe, and in the other the whole cut plant is harvested on the stalk. The first method, which is known as priming, gives greater uniformity, but the second is much less laborious. Both systems have been practised according to the variety and other conditions.

The green leaf when ripe measures in length, on the average, about 18 to 24 in., and in breadth about 8 to 12 in. The leaf should not be damaged in any way. To avoid this the plants, when cut whole, are usually allowed to lie on the field for some little time until they wilt or become limp.

Different methods are adopted for drying the leaf, entailing from expensive drying barns, heated with steam, to a very simple scaffolding construction. It has now been established that air-drying, supplemented by slight heat at certain stages, is not only the cheapest method of drying most classes of tobacco but is also the best. Hay-sheds, barns, lofts, and other open buildings have been successfully utilized for air-drying purposes. During the process of drying chemical changes take place which are exceedingly important, but which are not yet fully understood. Proper drying merely develops the qualities that have been accumulated during growth, so that a poor, badly harvested tobacco cannot be converted into a first-class sample by even the most elaborate system of drying. A first-class crop can, however, be completely ruined by careless or unskilful drying.

The treatment of tobacco, after being dried by the grower, is involved, and calls for a considerable amount of trade skill and judgment. For these and for other reasons, the after-treatment of the product is better left in other hands than those of the grower. This does not, of course, preclude the co-operative curing of the crop under the grower's control.

Varieties.

The tobacco crop thrives in many parts of the world, and as already indicated, several hundred varieties are in cultivation. A great number of these have been already tested in the home countries. Efforts have been made, during the past twelve or fifteen years, to establish, by comparative tests, a limited number of varieties which would prove particularly suitable to our own conditions and requirements. As a result of these repeated tests, the following are some of the principal varieties that appear in the light of present knowledge, to be most promising:

Cigarette tobacco: Irish Gold (this variety is, however, very susceptible to the disease known as root rot); Samos and Latakia, cross varieties, which are root-rot resistant.

Cigar tobacco: Halliday.

Pipe tobacco, roll and plug: Copper King and Kentucky Black have proved suitable, but are both susceptible to root rot.

An Italian double hybrid called " Siky " produces a very fine leaf and is practically immune from root rot. Some other varieties such as Blue Pryor, Yellow Mammoth, Yellow Orinoco, and Burley types, together with some hybrids produced in Ireland, are still being tested with promising results. Pipe varieties can be grown more successfully in these countries than either cigar or cigarette types.

The seed of the tobacco plant can be grown and successfully matured both in Ireland and Great Britain; indeed home-grown seed has been proved to be more reliable and satisfactory than imported seed. For this purpose a few of the most shapely and well developed, thick-leaved plants should be selected before the flowers are formed. Each flower head must be covered with a paper or muslin bag or other contrivance in order to prevent cross-fertilization. One plant will produce sufficient seed for several acres.

Diseases.

The disease known as root rot has spread through many tobacco-growing districts during the past few years. In practically every case the disease appears to be traceable to the seed-bed, where the conditions are very favourable for its development. It is a fungoid disease and is exceedingly difficult to eradicate once it becomes established.

It is recommended as a preventive to change the site of the seed-bed

each time, to select good, fresh, well-decayed soil, and to disinfect the frames and sashes each year with a 2 per cent solution of sulphate of copper (bluestone). This disease has caused much and widespread damage in America, where growers are now trying to combat it by attempting to breed immune varieties. This undertaking is proving very difficult.

General.

The yield of the tobacco crop varies considerably according to variety and other causes, but 1000 lb. of dry tobacco per statute acre might be taken as a conservative average yield for these countries. As in most other industries a certain amount of local technical knowledge is essential in tobacco growing. The experience gained during the past fifteen years is of great value in this respect as a necessary preliminary condition for the reintroduction of the crop. It must not be assumed, however, that there is a "gold-mine" in tobacco for the grower; like most other farm crops it yields little more than an average return upon the capital required to produce it. It is nevertheless regarded as a valuable farm crop from a national point of view, because it gives fairly regular employment to a large number of people, including light labour, which can be done by women and children in their spare time, and because the product, when properly turned out, can be safely and cheaply transported even to distant markets.

HEMP

By J. VARGAS EYRE, M.A., Ph.D., F.I.C.

During recent times the term " hemp " has come to signify not only the particular fibre yielded by the hemp plant *Cannabis Sativa*, but a class of fibre considerably coarser than flax, used in the manufacture of heavy fabrics, twines, and ropes. Thus fibre from the non-edible banana (*Musa textilis*) is known as Manila hemp; fibre from *Agave rigida* as Sisal hemp; from *Furcræa Gigantea* as Mauritius hemp; the fibre from *Phormium Tenax* as New Zealand hemp; and many others. The true hemp plant (*Cannabis Sativa*) is a native of Central or Western Asia and belongs to the nettle family. It is a diœcious species, the male and female characters appearing on separate plants, and its economic importance lies chiefly in the fact that its outer bark yields a fibre of great strength and its seed contains a considerable proportion of oil.

Some of the very earliest writings known to us contain references to hemp and to articles manufactured from its fibre; indeed, it may be regarded as the earliest cultivated plant for the production of fibre for textile and cordage purposes, while its seed, in ancient times, formed an article of food.

Considering the great antiquity of *Cannabis Sativa* as a cultivated plant, it is somewhat surprising so few varieties are known. Whether this is due to the comparative readiness with which it adapts itself to almost any conditions of soil and climate, or whether due to lack of attention by cultivators, it is impossible to say. Of the several recognized varieties which are grown for commercial purposes one may mention the Chinese " Giant Hemp ", which reaches a height of nearly 20 ft.; the variety grown in the district of Bologna, known as " Great Hemp ", which attains to some 12 to 15 ft.; Russian hemp, which grows to about 6 to 10 ft., which is the form more generally grown in France, Belgium, Hungary, and until recent times in the British Isles; Tuscany, or " Small Hemp ", which has slightly pink stems and grows to about 4 to 6 ft. high, and a dwarf variety, reaching only to about 3 to 4 ft. high, which is a less well-known variety, grown in Manchuria for its seed.

The introduction of hemp into the British Isles, like that of flax, was probably due to the visits of traders to these shores from eastern Europe long before the Christian are. Until the beginning of the fifteenth century, however, very little information is to be found, although it is clear from early writings that hemp had by that time become an extensively grown crop in England. Since then it became cultivated in nearly every part of that country, the fibre being separated and prepared for market as part of the agricultural practice of the day, thus giving skilled employment to considerable numbers of people in the winter months. During more recent years, the troublesome operations of separating the fibre from the plant and of preparing it for market, taken in conjunction with low prices and poor seasons, have so militated against the success of hemp cultivation, that at the close of the nineteenth century scarcely any was grown in the United Kingdom. Since then this situation has not become changed, so that in considering hemp as a field crop one looks to the future, when improvements, more particularly in the after-processes of fibre separation, may make possible the establishment of such operations as an organized rural industry, apart from actual crop production, and give fresh impetus to hemp growing.

The most suitable soil for hemp is a deep rich loam containing plenty of humus and a good proportion of sand, causing it to work freely and keep open in texture, land such as may be found extending over large parts of Lincolnshire, Cambridgeshire, Suffolk, and parts of the west and south-west of England being eminently suited. Hemp makes only poor growth on soils of acidic character or where a good tilth cannot be produced, nor does it thrive where the land is wet, although it enjoys a rather moist situation. It is a crop peculiarly suited to warped areas and flat lands lying adjacent to rivers which are subject to winter flooding.

As with hop growing at the present day, so with hemp in the past, the practice was developed of reserving a special field or plantation for the crop, which was specially prepared and manured year by year for long periods. Although this practice has long ceased, "hemp fields" are still known in the districts mentioned. More recently hemp has taken the place of fallow in the short rotation—potatoes, hemp, wheat—adopted with success on the rich alluvial soil of the Cambridge Fens. Hemp was frequently grown after wheat and in some districts it followed a fallow or green crop, being followed itself by oats. On account of the rapid growth of the plant it is essential that the land be brought into good condition. Deep ploughing in the autumn and cross ploughing in the spring, followed by harrowing and rolling, is the usual procedure in preparing a fine level seed-bed. A liberal dressing of old farmyard manure is given in the autumn, and unless the land is exceptionally rich, phosphates and potash are applied in the spring. It is held by many that hemp is an exhausting crop, but when this question is examined

and due regard given to the large quantity of leaf material left on the ground, and of the root and stubble which remains behind, all returning nutritive materials to the land, it is found that this crop does not impoverish the land to a greater extent than would a wheat crop raised under similar conditions.

The best seed to sow comes from the Baltic or from the valley of the Loir, in Sarthe, preference being given, however, to that which is exported from Riga. Sowing seed should be freshly imported, because, owing to its high oil content, it is liable to deteriorate when stored, unless special care is taken. Good seed is bright, heavy, and plump, is of a brownish grey colour, and possesses a slightly sweet nutty taste. The seed should be sown about the latter part of April or the beginning of May, either broadcast or in drills. If a fine-quality fibre is desired, 3 bus. per acre of good germinating seed should be sown broadcast or about 2 bus. if the seed is drilled. The practice of drilling hemp is much to be preferred. After some four or five days have elapsed the plants make their appearance, and soon afterwards they should be thinned to about 8 or 10 in. apart. Sometimes, for the production of a higher yield of seed and a coarser kind of fibre, about 1½ bus. per acre is sown with an ordinary corn drill, and beyond removing the larger weeds no further cultivation is given. Hemp grows very rapidly and so shades the ground by its foliage that scarcely any weeds grow.

Before long the male plants may be distinguished from the female plants by their less robust growth, and about three months after sowing by the profusion of their flowers and the abundance of pollen which they shed. Soon after this the leaves of the male plants assume a yellow colour and their stems become whitish grey, whereas the female plants remain in full vigour. At this stage the male plants are harvested for separate treatment, but the female plants are allowed to remain until their seed capsules are well filled and upon examination reveal a well developed seed just assuming a pale brown colour—a stage of development which is reached some six weeks after the male plants are ready to harvest. In this way two harvests are taken, the male or summer hemp and the female or winter hemp each being separately treated to free the fibre from the stems. It should be mentioned that the fibre obtained from the male is of greater value than that which is obtained from the female plants. A more recent practice has been to abandon this double harvesting and to allow the male plants to stand until such time as the female plants are ready, when the whole crop is cut either by hand or by a reaper. This plan is far more economical of labour, but results in a much less valuable product being obtained.

A good crop raised from Russian seed will weigh some 3 to 4 tons per acre when harvested, and will yield 12 to 15 bus. of seed and about 40 stones of raw fibre. To secure this seed the harvested crop is gathered

into loose stooks, and left to ripen and to dry until the seed capsules can be rubbed easily from the stalks and the seed is freely shed. The stooks are then removed to a spread sheet and the seed threshed out by hand if the quantity is small, or the heads cut off and threshed separately by machine.

Probably on account of the pungency of its foliage, hemp is remarkably free from diseases and pests. The only serious trouble caused sometimes is by the Broom Rape (*Orobanche ramosa*), which is a parasitic weed attaching itself to the root of the hemp plant. The seeds of Broom Rape are extremely small and easily overlooked; moreover, they stick to the exudation from damaged hemp seed and escape detection, so that it is wise to examine sowing seed carefully and to use only that which is thoroughly dressed.

The fibre of the hemp plant is situated just beneath the outer bark of the stem, and forms a more or less continuous band of irregular bundles of individually fine but long fibres. This band of fibrous material is freed from the surrounding tissue and is to a considerable extent broken down itself by the decomposition of the pectous substance which serves as the binding material. From times immemorial this has been effected either by tying the harvested stems in bundles and submerging them in the water of a small pond or stream, or by spreading the loose stems in an orderly manner over stubble or grassland, so as to allow the dews and rains, similarly but more slowly, to effect this decomposition. In each case the object is ultimately to achieve the easy separation of the fibrous layer from the " reed " or inner part of the stem. These operations are known as " water-retting " or " dew-retting " respectively, or as " steeping " and " grassing ", and involve in the one case the anaerobic, and in the other case the aerobic bacterial decomposition of the pectous substance referred to.

Stagnant or slowly moving water is preferred for steeping, and in this operation the bundles of straw are piled one upon another so as to form a kind of raft, which is then covered with a little straw and completely submerged by placing upon the raft planks and large stones. Under moderately warm weather conditions the male stems are sufficiently retted in about four or five days; the female stems, however, becoming available so much later in the season, require almost twice as long to arrive at the same stage of retting. By frequently examining drawn stems, experience enables one to decide when the retting process has proceeded sufficiently far, and the ultimate value of the fibre depends very largely upon this decision. Then the bundles are withdrawn, washed in clean water, and dried by spreading them on grassland. The alternative method, namely of dew-retting, has been adopted more generally with the female stems as they become available in the autumn. Either then, or in the early spring, these stems are spread in regular rows over grass

or stubble land where they are allowed to remain for several weeks, being turned over once or twice in order to secure as far as possible a uniform product. By whichever method the stems are retted, when the decomposition is adjudged to be sufficiently advanced they are gathered up and stored under cover until the final operation of separating and cleaning the fibre can be undertaken.

As will be understood, retting calls for special care not usually available on a farm at the present day, and attempts have been made, not without success, to dispense with the process altogether and to pass on to the final operations of "breaking" and "scutching" just as though the stems had been retted. In this way a less valuable fibre is prepared, known as "green hemp".

In breaking and scutching the retted stems are passed between fluted rollers, or are drawn beneath grooved levers, so as to break the brittle "reed" or central part of the stem into small pieces without damaging the loosely adherent fibre. These pieces are then completely removed by beating small handfuls of the broken hemp in a downward direction with a wooden blade, while held over an upright post. This is known as "scutching" or "swingling", and may be performed also by some simple mechanical device which effectually knocks out the broken reed without damaging the fibre. The resultant long fibre is made up carefully into bundles each weighing a stone, and in that form the fibre is sold.

CHICORY

By W. G. SMITH, B.Sc., Ph.D.

Chicory or Succory (*Cichorium intybus*) may be grown as a crop for the roots, for the young leaves as a garden vegetable, as a forage plant for stock, or as a constituent of grass mixtures for pasturage. It belongs to the order Compositæ, and to the section with the head or capitulum made up entirely of florets with strap-shaped flowers. The bright blue flowers, about an inch across, distinguish chicory at once from the other commoner British genera with strap-shaped florets which have yellow flowers (Dandelion, Sow Thistle, Hawkweeds, and Hawkbits). As with all Compositæ the head consists of a number of florets each capable of producing a one-seeded fruit or achene, generally known as a seed. Chicory seed is about $\frac{1}{10}$ in. long, blunt wedge-shaped, squared at the angles, straw-coloured mottled with dark spots, and marked across by fine wrinkles. The feathery pappus, found in thistle or dandelion, is absent in Chicory except for a crown of minute scales. Common seeds resembling Chicory are Mayweed with smaller seeds, and yellow Corn Marigold with deeply ribbed seeds. Chicory is sometimes found as an impurity in Red Clover seed, often in the Chilian variety, and thus it may appear in fields where not sown. It is not a common plant in Scotland, but becomes commoner in England and is a field weed in Western Europe and in parts of America. Young plants of Chicory resemble Lettuce, Sow Thistle, and Dandelion in that a rosette is formed by the first leaves, which are elongated wedge-shaped with sharply cut wavy margins. Like these other plants, it quickly forms a deep tap-root which if bruised gives off a milky juice, and the same can be seen on bruising the leaves and other parts. Chicory is a perennial, flowering in the second year or later if not grazed. The flowering stems may be 3 ft. high, scantily furnished with leaves, and bearing the flower heads generally in pairs on short stalks. At this period the taller stems soon become hard, are neglected by stock, and if allowed to mature look from a distance like seeding Docks in the field.

Chicory as a vegetable has been long known in the kitchen garden. Endive differs little in appearance but is an annual, and being less robust in habit lends itself better to culinary purposes. One or other of these plants may be used as a green salad like Lettuce, or boiled like Spinach. The young shoots from perennial roots may also be forced by heat in darkness, and blanched to serve as a substitute for Sea-kale or Asparagus.

Arthur Young in the latter half of the eighteenth century strongly recommended Chicory as a forage crop for stock. The earlier tendency was to grow it as a green crop, using the herbage for stock feeding and the roots as an additional crop. This, however, cannot be recommended, as if the foliage is heavily cut the root produce is reduced. Older accounts state that Chicory may be cut three or four times a season, yielding a large amount of fodder, but at the present time there can be little doubt that vetches and other leguminous plants with oats or grasses will give a larger and more useful crop for fodder or silage. Chicory may have its uses on deep light soils, but the amount of labour required will operate against its value.

As a plant for including in grass and clover mixtures for three years or more, Chicory now holds a prominent place. 2 or 3 lb. of seed per acre sown in a grass seeds mixture gives a considerable number of plants, already well rooted in the autumn stubble and carrying a few leaves. Sheep are especially fond of it, and after a short period of grazing it will be seen that almost every plant of Chicory has been more or less grazed. It has also an attraction for hares and rabbits, as soon can be observed in enclosed experimental grounds where these have found access. Where sheep are grazed, Chicory rarely shows excessive growth and tends to disappear in a few years. It has been recommended in grass mixtures of the Elliot type, where the inclusion of deep-rooted plants (Chicory, Kidney Vetch, Burnet, &c.) is claimed as an advantage. In many grazing districts Chicory has now replaced Sheep's Parsley and Yarrow as an additional plant in grass and clover mixtures. It stands drought and frost well, especially on deep open soils where the roots can penetrate, and on such soils it resists grazing longer than on soils over a compact subsoil. The presence of lime seems to favour its growth. Chicory has no special advantage in hay (unless cut early the flowering stems soon become hard and woody), but with a sowing of 2 or 3 lb. of seed the amount will not depreciate the hay.

Chicory is also grown as a root crop, mainly as a substitute for or as an adulteration in coffee. The powdered root on being infused in boiling water gives a sweet dark-coloured fluid with a peculiar flavour, which, according to taste, may be regarded as pleasant or unpleasant in coffee. The encouragement of Chicory, like the cultivation of sugar beet, in Europe was a result of the Napoleonic wars, when the strict blockade of Europe made it necessary to find home-grown sources for materials, like coffee

and sugar, previously imported. Chicory is still largely grown in all countries where coffee is in general use, especially in Belgium, Holland, France, Germany, and neighbouring countries. Little Chicory is grown in Britain, the returns giving 391 ac. in 1912 but only 77 ac. in 1914, and although something like the higher figure was reached during the war years, a decline has again set in. The amount of home-grown Chicory charged with duty by the Excise was about 185 tons in 1912–3, over 500 tons per annum between 1916 and 1918, and 150 tons in 1920–1. On the other hand, the imports are considerable; for the pre-war years it was considerably over 5000 tons per annum, but only part of this, about 3000 tons per annum, is retained for home consumption. Most of this comes from Belgium and adjoining countries, and represents the produce of about 2000 ac.

The cultivation of Chicory is comparable to that of sugar beet, in type of soil, the amount of labour, and the necessity of finding a market for the roots, which have to be further prepared by drying and grinding, operations not generally done by the grower. The cost of production is high since it includes deep preparation of the soil, good manuring, careful cultivation, singling by hand, digging and washing the roots. The soil must be deep, as good Chicory roots should be 15 in. or more in length and not too slender. In Britain the crop was often taken after potatoes or wheat. On the Continent it is frequently grown to rest sugar beet land. If taken after cereals, about 10 tons of farmyard manure are applied in autumn, and the soil is again worked to prepare a fine seed-bed in spring. Artificial manures are generously supplied in Belgium. Sowing takes place about May, as early sowing encourages the formation of flowery shoots in the first year, thereby depreciating the roots. The amount of seed is 3 to 6 lb. per acre, drilled 12 to 18 in. apart. Certain varieties are more suitable as a root crop, especially Palingkop and Magdeburg, both with long clean tap-roots. Thinning takes place when the seedlings have about four leaves, plants being left not less than 6 in. apart, sometimes even 10 in. This has to be done by hand or with a fork to remove the long roots which if left may throw out new shoots. Later operations consist in cultivating to keep down weeds, and the removal of flowering plants. The roots are lifted about October by spade or fork, or by special diggers, to avoid breaking the tap-roots. Careful removal is necessary, as "ground-keepers" become weeds in succeeding crops, and if allowed to flower and ripen seed Chicory may become a serious weed. This probably explains why Chicory has never been a favourite crop in Britain, and in the United States a recent author describes it as "just a weed and a very persistent one". The cost of cultivation (pre-war) in Belgium and France is given as from £12 to £14 per acre, which with a crop of 10 tons of roots means up to 28*s.* per ton.

The harvested roots are generally washed by the grower. Later operations belong more to a special factory, where the roots are again washed, sliced into thin discs by a machine, and dried on a kiln. Chicory dried for twenty-four hours at about 140° F. is known as " ordinary dried Chicory ". About 4 tons of fresh roots are required to produce 1 ton of dried root. During storage, heating and deterioration may set in unless the store is kept dry. Chicory imported into this country from Belgium is generally " high dried " at a higher temperature to remove more moisture, thus reducing weight.[1]

Chicory root is subject to taxation by the Customs and Excise; imported raw or dried root at 39*s.* 8*d.* per hundredweight, roasted or ground at 6*d.* per pound; home-grown raw or kiln-dried pays 38*s.* 6*d.* per hundredweight, being 1*s.* 2*d.* per hundredweight in favour of the home grower, and under certain conditions there is a rebate for empire-grown produce.

Fresh Chicory roots contain about 80 per cent of moisture. When dried and ground (" Chicory crumbs ") the composition is approximately 14 per cent moisture, 70 per cent carbohydrates and ash, 5 per cent protein, 1 per cent fat. The carbohydrates include sugar, about 5 per cent in dried roots, and up to 8 per cent in roasted, also inulin, about 17 per cent, a carbohydrate found also in Jerusalem artichoke and other Compositæ.

Chicory as an addition to coffee owes its properties largely to these carbohydrates. It increases the sugar content of coffee, and on roasting, the sugar is transformed into caramel providing a sweeter and darker coloured liquid on infusion. Pure roasted chicory has three to four times the tinctorial power of roasted coffee. The large amount of soluble inulin, added to the soluble sugars, also increases the body of the infusion; thus a 10 per cent infusion of pure coffee has a specific gravity of 1·008, whereas a comparable infusion of pure Chicory is 1·0226. Amongst other properties, the addition of Chicory decreases the fatty matter, which may be up to 20 per cent in coffee. Chicory contains neither caffeine nor tannin, both present in coffee, hence its presence reduces the amount of these in infusions. It contains, however, a small amount of a bitter glucoside, which brings into the mixture part of the peculiar flavour. Whether Chicory is to be regarded as a useful addition or as an adulteration of coffee is largely a matter of taste, but as chicory is much the cheaper constituent its addition opens the way to increased profit.

Recent experiments indicate that during a scarcity of oats, Chicory could be used for stock-feeding as a substitute, but in Britain this does not seem a probable need.

[1] See also *Journal of the Board of Agriculture*, London, Vol. XXI, Feb., 1915.

BUCKWHEAT

By J. G. STEWART, M.A., B.Sc. N.D.A., N.D.D.

Buckwheat, though reckoned as a grain crop, is not a cereal, for it belongs to the natural order Polygonaceæ, an order which includes many of the common weeds of the farm, e.g. Bindweed (*Polygonum convolvulus*), which it closely resembles, and also Sorrel and Knotweed. The name "Buckwheat" corresponds with the Dutch "Bockweit" or German "Buch-weizen" meaning "beech wheat", from the resemblance of the seed to the beechnut.

Buckwheat is grown in most European countries in the temperate zone, also in America and Canada. In England its cultivation is confined mainly to the Fen districts and the poor light land areas of East Anglia.

Claims of Buckwheat.—It is chiefly as an auxiliary grain crop, rather than as a substitute for the cereals, that this plant claims attention. The grain is similar in composition to that of cereals, and if used judiciously forms excellent feeding material. It will yield an appreciable crop on sandy or gravelly soils too poor even for rye, and as it requires only from twelve to fourteen weeks to mature it can be sown late and take the place of crops that have failed or which could not be sown at the proper season. It is practically immune from insect pests, and is, therefore, a safer crop than cereals after old grass or when breaking up fresh ground. It is a useful "smother" for weeds, and leaves the land in fine friable condition for the succeeding crop. It is also valuable for green forage, for green manure, and as a source of honey for bees.

Varieties.—Of three main varieties of Buckwheat in cultivation, only one, *Polygonum fagopyrum*, is in general use.

Description of Plant.—Buckwheat is an annual plant, the stem of which is greenish or purplish red in colour, changing to brown as maturity is reached. Each seed produces but one stem with an erect, branching habit of growth, and a primary, branching root. Under favourable conditions the plant may reach a height of 3 ft. or more, but a too luxuriant

crop is apt to lodge, making harvesting difficult or impossible. The flowers are white with a pinkish tinge.

Soil and Climate.—The crop is adapted to a wide range of soils, but is best suited to warm well-drained sandy loams. On fen or other rich soils it grows luxuriantly but is very liable to lodging, a state from which it cannot recover. From an economic point of view it cannot, however, compete with cereals under such conditions, and is usually only sown after a failed corn crop or in circumstances which prevent the sowing of cereals in due season. It will not thrive on cold wet soils. Its special merit lies in the fact that it will do well on poor thin soils, on the verge of cultivation, where other grain crops would starve. Such soils are frequently deficient in lime, and but for such crops as Buckwheat, lupins, and to a limited extent rye and potatoes, which are not very sensitive in this respect, would remain uncultivated.

As regards climate, low temperatures are a serious danger; the plant may be destroyed by a single night of frost.

Place in Rotation.—In general, no special place in a rotation is taken by this crop, for the reasons indicated. Belonging, as it does, to an order of plants which differ in their food requirements from cereals, it is well adapted for following or preceding a corn crop, and owing to its mellowing effect on the heavier soils it forms a good preparation for roots. It may be grown year after year on the same land with little or no apparent ill effect if properly fertilized, but on the poorest and thinnest soils, for which it is specially applicable, the following would be the natural system of cropping to pursue: lupins, Buckwheat, potatoes, rye.

Preparation of Seed-bed.—As a rule, the minimum amount of labour is expended on soil preparation, although more thorough cultural treatment would be well repaid. After a corn failure the land is usually either harrowed or disced. On the lighter soils a simple ploughing followed by harrowing and rolling to preserve moisture is generally all that is required. Heavier soils should be ploughed in time to secure a fine surface tilth and light soils worked so as to retain moisture. In general, the cleaner the soil and the finer the tilth the better will be the results.

Manurial Requirements.—Manures are rarely applied directly to Buckwheat, the remains from previous applications being generally regarded as sufficient. When, as is usually the case, the soil is poor it is often profitable to use fertilizers. Phosphates are likely to be needed most, and may be used to the extent of about 2 cwt. of superphosphate per acre. It would appear, however, that soluble phosphates are not essential; experiments at the New Jersey Agricultural Station indicate that Buckwheat will utilize the insoluble phosphates of rock phosphate almost as readily as soluble phosphate. As regards potash it seems prob-

able that, on all but the poorest soils, Buckwheat can secure sufficient of this ingredient for its requirements. Where potash is markedly deficient about 2 cwt. of kainit per acre should be given. As for nitrogen, other crops grown in the rotation, e.g. lupins, should supply sufficient nitrogen in a more suitable form and at a lower cost than is possible by other means.

Seeding.—The best time for seeding is the end of May or the beginning of June when the risk of frost is past. The seed should be of good weight (about 50 lb. per bushel) and of satisfactory germination. It may be drilled in the same way as corn, when about 2 bus. per acre are required, or it may be sown in rows about 14 in. apart, when 1 to 1½ bus. will suffice. Drilling is usually preferred to broadcasting, but the latter is not infrequently practised with good results, at the rate of 3 bus. per acre.

It is a mistake to bury the seed too deeply; from ½ to ¾ in. is sufficient. Provided the seed-bed is clean no further cultivation is required.

Harvesting.—The crop is usually ready for cutting about the end of August or the beginning of September. Ripeness is indicated by the general browning of the crop, and harvesting should begin when the majority of the seeds have formed and before the earliest have fallen. Even at this stage flowers, which are produced in succession right into late autumn, will be noticeable on some of the branches.

The crop is usually cut with a scythe or with a side-delivery reaper, and left to dry for some days before being tied and stooked. Sometimes it is cut with a binder, but in this case drying, on account of the sappy nature of the straw, is rendered more difficult. When thoroughly "won" the crop is carted and built into small stacks with, here and there, a layer of dry straw to take up the surplus moisture.

Threshing and Yield.—Buckwheat threshes easily, and, to avoid cracking of the grain and undue breaking of the straw, the threshing machine should be fitted with a smooth concave. Small quantities may be threshed by flail provided the straw is thoroughly dry.

The yield of grain varies greatly, the average being about 3 qr. per acre. (The weight per quarter is usually reckoned as 28 st., i.e. 392 lb.) On poor soils less than 3 qr. may be obtained, while on better land the yield may be as high as 6 qr. per acre. As generally grown, the cost of cultivation is small, while the price obtainable normally is about 4*s*. per quarter less than that for wheat.

Uses of Buckwheat. (1) *Grain.*—In some parts of the Continent and in America the grain, after milling, is used for making bread and cakes for human consumption. Under favourable conditions 100 lb. of grain will produce 60 lb. of flour, 24 lb. of middlings, and 16 lb. of hulls.

The milling process is described by Wiley in *Foods and their Adulterations* as follows:

"During the process of milling the Buckwheat grains pass to a receiving separator which removes all the coarse particles, stones, straws, &c., by means of a series of sieves. At the same time, any dust which they contain is blown out by a current of air. The sifted grains pass next to the scouring machines, in which they are thoroughly scoured, cleaned, and polished. From these machines the grain is passed to a separator containing magnets by means of which any pieces of metal, in the form of nails, screws, pieces of wire, &c., are removed.

"The grains next pass through a steam dryer for removing the greater portion of the water employed for the scouring. As soon as they are dry they are again treated to a blast of air, which removes any dirt, dust, or light particles which may have been detached during the process of drying. The grains next pass to the shelling rolls, where the greater part of the outer hulls is removed. This process is accomplished by means of an apparatus which is called a sieve scalper. After the separation of the outer hulls the residue of the material passes through a drying chamber, where the moisture is reduced to about 10 per cent, thus ensuring the keeping qualities of the flour. After drying, the grains are ready for the rolls. After entering the rolls, the process is practically the same as that which is employed in milling wheat, consisting of a series of breaks and reductions, with the attendant bolting and grading, and this process is prolonged until the flour is practically removed from the feed or middlings."

In this country Buckwheat grain is chiefly used for the feeding of game and poultry. As a feeding stuff it is relatively high in fibre, otherwise it is not dissimilar in composition to barley and oats, as may be seen from the following table prepared by Crowther.

	Water.	Albuminoids.	Fat.	Carbohydrates.	Fibre.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Buckwheat ..	13	11	2	60	12
Barley ..	14	10	2	67	5
Oats ..	13	12	6	55	10

Cracked or ground, and mixed in small quantity with other feeding stuffs, Buckwheat is a safe and useful food for all classes of farm animals. When, however, it is eaten constantly or in too large quantity it is apt to cause digestive trouble.

Buckwheat middlings, obtained in the making of flour, are considered a valuable ingredient of a feed mixture especially for milk cows, being low in fibre and particularly rich in albuminoids and mineral matter, but they should never be used alone.

(2) *Straw.*—Buckwheat straw is sometimes used for feeding purposes

when chopped and mixed with other fodder. As litter it is quite useful, and as it is rich in mineral matter and rots quickly it makes good manure.

Buckwheat as Forage.—In Hungary a mixture of equal parts of Buckwheat, field peas, and vetches is recommended as a fodder crop for dairy cows, and in the Harper Adams soiling experiments good results have been obtained from the following mixture sown at the end of May and fed green from the middle to the end of August:

	Per Acre.
Buckwheat	1 bus.
Peas	1 bus.
Rape	4 lb.

Buckwheat as Green Manure.—On account of its dense, smothering growth, Buckwheat is useful for clearing the land of weeds; it is also an excellent means of adding humus to the soil. As already stated, it grows quickly and is adapted for sowing late; thus, in circumstances where farmyard manure is not available, Buckwheat may be sown after a summer crop is off the ground and will provide a large bulk of readily decomposed material for ploughing under in autumn in preparation for a subsequent crop. For building up " condition " in poor, light soils and improving the texture of heavier soils, Buckwheat deserves to be better known.

Buckwheat as a Honey Plant.—The flowers of Buckwheat furnish an excellent and prolonged source of honey. Each plant produces many flowers over a period of four weeks and upwards. It is estimated that an acre of Buckwheat is capable of supplying as much as 150 lb. of honey in a season. The honey is dark in colour and of distinctive flavour, but is quite wholesome.

MUSTARD

By FRED. A. SMITH and W. J. MALDEN

There are two quite distinct varieties cultivated for seed, *Sinapis nigra*, Black or Brown Mustard, and *Sinapis alba*, White or Yellow Mustard.

The flour obtained from the two kinds of seeds finely ground and judiciously mixed forms the mustard of commerce, which is known as the national condiment—the manufacture of which is essentially a British industry.

White Mustard is grown for sheep feed, for ploughing in as a green manure, and also for salad purposes. Brown Mustard is cultivated solely for its seeds.

Brown Mustard.

Soil.—This requires a deep, moist, well drained fertile soil, free from acidity, and should be confined to the rich fenlands and alluvial marshlands of Lincolnshire, Cambridgeshire, Huntingdonshire, and Norfolk. It is one of the safest crops to take on newly ploughed out good grassland where cereal crops would grow too rank and become lodged or suffer from attacks of wireworm.

Rotation.—The position of Brown Mustard in the rotation of crops may be varied according to circumstances and seasons. On very good newly ploughed grassland Brown Mustard is often taken two years in succession—as a rule the second crop proves the more remunerative; third year potatoes, fourth year mustard again, then wheat or oats; or the rotation may be potatoes, mustard, clover, potatoes; or mustard, corn, potatoes, mustard. It will also do well after turnip seed.

Seed-bed.—The ground requires to be well worked so as to form a fine, fairly solid seed-bed with a good tilth. Given a good seed-bed the firmer the land is the better.

Manuring.—If the land is in good heart the only manure required is 3 to 4 cwt. of superphosphate per acre; in other circumstances a good dressing of farmyard manure, say 10 to 15 tons per acre, should be given in addition.

Seeding.—Brown Mustard may be drilled from the beginning of March to the middle of April, or as early as the middle of February if weather is favourable. The seed should only be very lightly covered; it should be drilled without weights and the coulter ridges left as a slight protection for the tender seedlings against wind. When the plants can be seen from end to end of the drill row, the crimp or flat roller should be run over them; when the crop is 3 to 4 in. high, a light seed harrow may be used lengthwise. 3 to 4 lb. of seed per acre is ample. The seed should be drilled on the flat in rows 15 to 18 in. apart, and the plants chopped out 10 to 12 in. in the rows so as to give room for branching. Most new growers make the fatal mistake of leaving the crop too thick on the ground; they have not sufficient faith. Others of more experience say if they can step from plant to plant in the early stages of the crop they are satisfied. Certain it is, if the side shoots have not room to branch and develop a heavy yield cannot be expected.

Harvesting.—Great care should be exercised in judging the correct time to cut. If cutting takes place too early the seed will become shrivelled, while if delayed too long there is considerable loss, especially in windy weather, through seed shelling on the land. Experienced growers say they wait until the pods assume the brownish tint of a hare's back. It is advisable to cut the crop slightly on the green side and give it "field room", to enable the plant to dry out thoroughly. When cut, the crop is allowed to lie for three or four days, then turned while damp with dew to prevent shelling. Mustard is generally cut by hand with sickles, tied with its own straw or with twine, and laid on the ground in small bunches; but when there is scarcity of labour or the workers are not used to this form of cutting, a sail reaper or, if the crop is a light one, a binder does the work well. If a binder is used it will work more easily if a man is placed at each corner to follow and assist the seed on to the canvas, as it is liable to bunch badly. Small sheaves should be made and not tied too tightly, and the crop should be cut as high as possible so that the high stubble may facilitate the drying of the sheaves. These should be turned after two or three days, and carted when thoroughly dry; dew must be well off the crop. In carting care must be taken to prevent loss of seed; cloths should be put over the racks or frames fixed to the carts to catch any shed seed, and this should be distributed over the stack from time to time and not laid in heaps, otherwise the seed will become mouldy.

Stacking.—A good bedding is necessary. This may consist of faggots or bushwood covered with straw or coarse grass, on the top of which should be placed a cloth or old bags to catch any shelled seed. If these are not available a layer of hay may be placed on the straw, &c., to catch the shelled seed. At threshing time the hay is rolled up and passed through the drum.

Threshing.—This is done with the usual tackle, the only extra parts required being four sieves of smaller size than those in normal use. Such sieves can usually be supplied by the makers of the threshing machines. Great care should be taken that the beaters do not split the seeds. The stacks require to stand at least six weeks to allow the natural "sweat" to pass off, otherwise the seed will thresh out soft.

Yield.—The yield varies very greatly. It may be as much as 20 cwt., but normally runs about 8 to 10 cwt. or a little more per acre. The chaff (pods) is used for feeding horses and cattle; the straw is practically of no value for fodder, but may be used for the bottoms of stacks and for cattle-yards, or as in some districts to form shelter walls around open cattle-sheds.

Some farmers are prejudiced against Brown Mustard growing because it "stains the land", i.e. plants appear in subsequent crops due to shelled seed. This, however, can be largely obviated if the field is dragged or harrowed as soon as the crop is harvested. The mustard will then grow and the plants can be ploughed in, thus adding to the fertility of the soil; failing this, the same treatment as for charlock may be adopted.

White Mustard for Seed.

Soil.—White Mustard is adapted to a much wider range of conditions than Brown Mustard, both as regards soils and weather, and causes less trouble from shed seed. It can be grown more or less successfully on all kinds of land. It is said that where turnips will grow White Mustard will succeed. It is a safe crop to take on freshly ploughed grassland. In the Fen district it is a common practice to take White Mustard after ploughing up temporary grass, i.e. grass that has been down from two to four years. On heavy clay lands it is often taken after fallows, the following crop being wheat. This system invariably proves a great success both as regards the mustard and the wheat. On heath and light lands it is taken before barley, and after swedes eaten off late with sheep, but the roll must be freely used if the weather is dry.

Seed-bed.—The ground requires thorough preparation and a fine and fairly solid seed-bed is essential.

Manuring.—If the land is in good heart the only manure needed is 3 to 4 cwt. of superphosphate per acre. In other circumstances a good dressing of farmyard manure, say 10 to 15 tons per acre, should be given in addition to the superphosphate.

Seeding.—White Mustard may be drilled at any time from the first week in April to the middle of May. If it is sown earlier it runs the risk of being cut off by the frost, but if the earlier sown crop is successful it has the advantage of coming to harvest before the corn harvest begins. If the seed-bed is sufficiently fine ½ pk. of seed, or slightly less, will be ample for 1 ac. On very light lands 1 pk. of seed per acre is

drilled. The seed should not be buried more than ½ in., or it will not germinate evenly; it is usually drilled on the flat in rows 12 to 18 in. apart. Some growers drill 12 in. apart and chop out the plants 9 in. in the rows, or to save labour run the horse-hoe across the crop; on good land the plants require more room to enable them to branch, but no thinning out is necessary on heath, light, or poor land.

Harvesting.—The methods of securing the crop and the precautions to be observed to avoid loss of seed are similar to those for Brown Mustard.

Stacking.—A good bedding or "steddle" is necessary. This may consist of faggots or brushwood covered with straw or coarse grass, on the top of which should be placed a cloth or old bags to catch any shelled seed. The stacks should be relatively small, about 4 yd. wide, to prevent overheating. In some districts stacking is obviated by threshing the crop in the field, but this is rather risky, as the seed tends to be soft, and it is safer, as with Brown Mustard, to allow the stacks to stand for about six weeks.

Yield.—The yield varies very greatly. It may be as much as 20 cwt., but normally runs about 8 to 10 cwt., or a little more, per acre.

The chaff (pods) is used for feeding, and in some seasons there is a good demand for the straw for cutting into chaff, and mixed with other things this makes a useful fodder, or it can be used in cattle-yards, and for the bottoms of stacks.

White Mustard for Folding and Ploughing In.

The White Mustard plant is quite distinct from Brown Mustard, and in favourable circumstances will yield to a much larger crop. The leaves are pinnatifid, the segments being lobed and rough. The flowers are a pale yellow, and the pods are spreading, short and rough with a dagger-like beak. Seeds are pale yellow and considerably larger than those of Brown Mustard.

Like other small seeds those of White Mustard require a fine seed-bed to germinate, and should be sown at but little depth below the surface. Where the crop is for fodder purposes the seed is sown broadcast—about 18 to 20 lb. per acre being used.

White Mustard is grown chiefly after a late bastard fallow, or after crops such as early peas, beans, &c., which are harvested sufficiently early. It is well to get it sown in July or early August, as if sown later it is not likely to crop so heavily, and may be damaged by frost before it grows to full bulk. In favourable conditions it is fit to feed in six to eight weeks after sowing. Where early sowing is possible, quickly maturing varieties of turnips are often grown along with the White Mustard. This mixture provides a useful feeding crop, and is often taken in seasons where, through drought or other causes, there is likely to be a scarcity of autumn

or winter feed. Mustard, however, cannot be relied upon after sharp frosts set in.

The chief purpose for which this crop is grown is to provide forage to be fed off by sheep. The feeding value, however, is rather low, and it is not suitable for cutting and soiling. It is also often used to provide green manure, and owing to its rapid growth it is successful as a catch crop. As a " nitrate catcher " it has been found useful. Unless when grown for seed production, White Mustard is not taken as a main crop.

Two or three crops of mustard are sometimes grown in succession and fed off by sheep or ploughed in, the first crop being sown in spring as early as there is a likelihood of the seedlings escaping late frosts. This system is better adapted to light than to heavy soils.

The dislike which wireworms have for mustard is sometimes an incentive to grow it. If any good results in checking this pest are to be obtained the seeding must be heavy, so that weeds will be smothered and no food left available for the insects.

When feeding off the crop to sheep, it is best to do so in the close fold, allowing a good fall back, so that the manure may be well distributed. In this way there is little waste. If fed off when the crop is very young sheep do not get much nutriment from it, and they are generally put on other feed during the day. On the other hand, if the mustard is allowed to get too old they refuse to eat any but the more succulent parts. Discretion must be used as to the best time at which to fold.

If the plants are allowed to become large and woody, there is difficulty in ploughing in the stumps, and it may be necessary to roll the field in the direction of the ploughing, or to use a bob weight and chain to drag the haulms into the horse-walk so that the furrow may cover them. It may also be necessary to roll the green crop when this has to be ploughed in. Care must be taken that the rolling is done in the direction in which the plough will travel, so that the least possible resistance is offered.

LINSEED OR FLAX

By F. K. JACKSON

This plant, *Linum usitatissimum*, is grown in most temperate regions of the world both for its seed, which contains a high proportion of oil, and for flax fibre, the raw material of the linen industry. The method of cultivation here described when seed is the principal object differs somewhat from that followed when fibre is the product desired. Since the prices of oil-cakes and other feeding stuffs have risen, the practice of growing a few acres of linseed has been increasingly followed, particularly on farms where calves are reared or cattle are fed and fattened off with a high finish. Few foods equal and hardly any excel linseed for these purposes, and it is beyond doubt that it can be grown on the farm at a cost very much below the market price, while the culture of the crop presents no special difficulties nor is it more subject to the influence of seasons than cereal crops.

At one time it was widely held that linseed was a very exhausting crop, imposing a heavy draft on the land, but this has not been supported by recent experiments, and it is significant that in those districts where the crop has been grown regularly for many years no such belief exists. Up to the year 1919 the agricultural returns include both linseed and fibre crops under the one heading of flax, but it is estimated that between 5000 and 6000 ac. of linseed were grown in Great Britain in each of the years 1918 and 1919.

Varieties.

Probably the variety best suited to English conditions is Plate linseed, coming from the Argentine. This is a large-seeded type, and has generally been found to yield better than Canadian, Algerian, Russian, or Dutch, though in a number of cases these have compared favourably. The Dutch White-flowering variety is characterized by a hardy growth, rather later ripening, and a long straw, and it is perhaps to be preferred where

conditions are not altogether favourable to the crop. Bombay seed generally produces shorter straw than any other variety mentioned, which is sometimes difficult to harvest on that account.

Soil.

A kindly friable loam on a cool clay bottom gives the most favourable conditions; light land if in good heart and heavier soils if a good seed-bed can be obtained are also quite suitable, but chalky soils do not usually give high yields. It is essential that the land should be well drained.

Rotation.

A linseed crop may be taken at almost any point in the rotation provided the land is clean enough, but extremes either of poverty or richness should be avoided. Normally it follows a first or second corn crop, preferably wheat or oats, or a clover stubble. Growing after roots or potatoes sometimes leads to a rank growth with a reduced seed yield, though this depends on the manuring of these crops. It is important to select clean land as weeds are very apt to grow ahead of the linseed, especially in a dry season. It is a common practice to sow a clover seeds mixture with the linseed, and this almost invariably leads to a particularly fine " seeds " crop, as linseed is an excellent nurse plant. Linseed also does well on newly ploughed grassland, generally making a bulky crop, and it is particularly suitable here in view of the fact that wireworms and leather-jackets do not harm it.

Manuring.

Farmyard manure should not be applied in large quantities directly to the linseed crop, as it is apt to cause a rank uneven growth with a tendency to lodging. If the land is not in fairly good heart a light dressing of short dung will be beneficial, preferably several months before sowing.

Preparation of the Land.

The aim of all tillage operations for linseed is to produce a fine but firm seed-bed free from weeds; no attempt should be made to grow it on foul land. The seed is small, and for this reason the young plant is sooner dependent upon the food material and moisture taken up by its roots than is the case with the cereal seeds, which carry in themselves a larger store of nourishment for the seedling. Hence it is important to provide a compact seed-bed so as to maintain a supply of moisture near the surface, at the same time keeping the soil sufficiently friable to allow of free root penetration. A seed-bed which would be considered just good enough for oats or barley would not as a rule be fine enough or firm enough for linseed. On strong land in particular early autumn ploughing is very desirable, and there is nothing but good to be gained from

deep ploughing so long as infertile subsoil is not brought to the top. An application of from ½ to 1 cwt. of sulphate of ammonia per acre is to be recommended, particularly after a wet winter and spring, together with 2 to 3 cwt. of superphosphate and on the lighter soils up to 1 cwt. of sulphate or muriate of potash; all should be broadcast immediately before sowing. It is important that the land should not be sour; should it lack lime a dressing of lump lime or ground lime should be given in the previous autumn. On the lighter soils, or where it is desired to apply lime in the spring before sowing, ground limestone or chalk would be safer and almost as efficacious. It has been found in Ireland with flax crops grown for fibre that the use of superphosphate encourages the growth of weeds to such an extent as actually to lessen the yield of flax, but this effect has not been seen in England or on the Continent where the use of phosphatic manures both for linseed and flax is common.

In preparing the seed-bed in spring on strong land, care should be taken not to bury the tilth or " crumb " produced by the winter's weathering. The land should be harrowed deeply enough to break the furrow crowns thoroughly; lighter harrowing should then follow, with a rolling to consolidate the surface even if it is not required to break down lumps. After a further light harrowing the manures and seed should be applied, harrowed in with light straight-tooth harrows (generally twice after broadcasting, once after drilling), and the field finally rolled. On light land of course the last rolling is particularly important, and if there is any risk of late frosts, another rolling when the plant is 1 or 2 in. high (but not before) will prevent injury. Linseed as a rule only suffers from spring frosts when the land is loose; on firm land even a series of white frosts will cause little or no harm.

If circumstances make it impossible to sow except on a cloddy seed-bed, and if rain falls after the plant is 1 or 2 in. high, a rolling at the stage when the clods are soft enough to break down without pasting will do much good in promoting evenness of growth, but the young plant should never be rolled when the soil is dry and hard. The depth at which the seed should be buried is always a compromise. If deep, the seedling has a surer supply of moisture, but it expends more energy in forcing its way to the surface. A depth of about 1 in. is generally most satisfactory. Much importance is to be attached to the preparation of a good seed-bed; most failures of the linseed crop are due to sowing before a satisfactory tilth has been obtained.

Sowing.

The large-seeded varieties of linseed (Plate and Algerian) are usually sown at the rate of about 2 bus. to the acre, but for the other varieties 1½ bus. is sufficient. Linseed is somewhat akin to wheat in that even

a thin plant may produce a good yield of seed owing to its propensity to branching when given plenty of room.

For seed purposes it is usually drilled in rows 8 to 9 in. apart to admit of easy weeding. In the south of England sowings may be made at the end of March, but in the north the middle of April is soon enough, and rather than sow in unfavourable conditions drilling may be postponed even to the middle of May. If desired the seed may be broadcast by hand or with a " fiddle ", but care must be taken to harrow thoroughly so as to bury the seed evenly.

Weeding.

Weeds of strong growth, such as Thistles, Docks, and Coltsfoot, should be carefully spudded out as from a corn crop, when the plants are a few inches high. It is very difficult to deal with a luxuriant growth of such soft weeds as Charlock, Poppy, Fat Hen, and Spurrey, and if the land is known to be infested linseed should not be grown unless such weeds have been dealt with before sowing by allowing them to strike and harrowing them out.

It is possible to kill Charlock in linseed by spraying with a 3-per-cent solution of copper sulphate, and little or no harm is done to the crop. If Couch Grass is present to any extent, sheep may be turned into the field when the plants are young; they will not eat the linseed, but if not given other food they will nibble the weeds.

Harvesting.

The crop can be cut as a rule with a self-binder, but if difficulty is experienced through the tough fibre of the stems clogging the knives, it can generally be overcome by using a grass mower with or without a manual delivery attachment, setting the knife at the higher speed if two are provided. In any case the knives should be kept very sharp. If only a small area is grown it may be pulled by hand or cut with a scythe. The sheaves should not be made more than 7 or 8 in. diameter, for if they become rain-soaked the heart of the sheaf does not readily dry out. For the same reason the crop should be stooked at once in rows of about ten sheaves carefully brought to a sharp ridge to throw off rain, with plenty of space between each pair of sheaves. The round stooks used in some districts are not suitable for linseed.

The crop may be judged ready for cutting when the seed is fully formed and just beginning to turn brown in most of the " bolls " or capsules. It ripens completely in the stook, and if left uncut till fully ripe much loss of seed ensues in handling. In most years harvest begins a week or two before corn is ready.

The linseed should not be stacked until it is thoroughly dry as it is more apt to heat than a corn crop. In showery seasons it is wise to build

"huts" somewhat in the form of a haycock standing about 7 ft. high, made up to a point with the root ends of the sheaves pointing downwards and outwards with no seed heads left exposed. The crop may then be safely left till a favourable opportunity occurs for leading.

Threshing.

Linseed can be threshed out in an ordinary threshing machine, the drum being set close to the concave, the speed kept well up, and the straw not fed in too fast. If the straw is at all moist, as may happen on a damp day, it may be necessary to put it twice through the machine. The screens must of course be altered to suit the size of grain; mustard screens usually suit the small-seeded varieties of linseed. Some makers provide machines with two drums which obviate any need for double threshing.

The chaff containing the brown leaves and capsule husks makes an excellent and much-relished feeding stuff for horses, cattle, and sheep, and it has been safely fed to them in large quantities.

Utilization of Straw.

As a general rule flax straw from crops grown for the linseed is not suitable for fibre-extraction. This is due to its branched and coarse character resulting from thin sowing; the variety being a short one or not carrying much fibre; the damaged and tumbled condition of the straw after being threshed; or to its frequently being harvested too ripe to yield fibre of good quality. In addition it would only be in the vicinity of a flax factory that a sale for this purpose could be effected owing to the cost of transport.

At one time a firm in the north of England used linseed straw for making coarse twines, and it is possible to use it for paper-making, but the uncertainty of supply and the large amounts necessary, have up to the present been an obstacle to any market in this latter direction. In practice the material generally goes for bedding in the fold-yard, where, however, owing to its hard nature it rots slowly, or it may be used for thatching when it is long enough. In a few cases it has been sold for packing earthenware, and in the United States one firm uses large quantities in the manufacture of insulating material for refrigerators, and there is also a market for it in that country for the manufacture of upholstery tow by factory treatment.

Yields.

The yields of linseed vary considerably with the conditions of soil and season. As much as 20 cwt. per acre has been grown, but a fair average may be put at 10 cwt. per acre with rather less than that amount of chaff. The straw remaining would weigh between 20 and 30 cwt. per acre.

Enemies of the Linseed Crop.

Fortunately few insect or animals pests attack this crop. Wireworm or leather-jackets seldom or never touch it, nor do rabbits cause damage save by treading down the young plants in their runs, but moles often do much harm by undermining large areas, causing the seedlings to die from drought. The Flax Flea Beetle, a similar insect to the turnip " fly ", occasionally attacks the seedlings, but seldom so severely as to necessitate a second sowing. The parasitic plant Flax Dodder is sometimes introduced into a crop through the seed, when it causes damage by climbing the stems of the growing linseed from which it takes much of its nourishment. The Dodder seeds are small and round and can be readily screened out of the linseed so that there should be no excuse for its presence.

Of fungoid diseases the most harmful is probably Flax Wilt, caused by *Fusarium lini* (Bolley). This fungus occurs in almost all flax-growing countries, and where soil is badly infected the condition known as " flax-sickness " is produced. The plants may be attacked at all ages, even before they appear above ground or when they are older and quite woody. The typical symptom of attack is withering of the leaves from lack of water caused by the fungus growing in and choking the water-vessels of the plant.

A species of Botrytis fungus appears to cause a similar condition when the plants are usually in a young stage, the point of attack being about ½ in. below the ground-level. Both diseases may persist in the soil for at least four years, and probably longer, even if no linseed is grown, as they are capable of living as saprophytes either on decaying pieces of flax or other vegetable matter.

The methods of prevention adopted are to allow a long period between two flax crops in a rotation—seven to nine years is common on the Continent—and to spray the seed immediately before sowing with a solution of formalin, 1 part in 300 parts of water. This operation should be done in the open field, the seed being turned with a shovel as the liquid is applied in the form of a fine spray. No more should be used than will wet the seeds evenly. If the grains become too wet the mucilage in the seed-coats swells and the seed cakes together, rendering even sowing impossible.

" Yellowing " is said to be due to the fungus *Asterocystis radicis*, and occurs when the seedlings are 1 or 2 in. high. A lack of potash in the soil appears to encourage it, but the evidence is not very clear on this point.

Under the heading of " enemies " may be mentioned the serious damage caused by hailstorms. This is most marked when the plant is grown for fibre, but if the plants are tender and sappy a bad hailstorm may cause great loss of seed by checking growth. The risk is often covered by insurance.

HEATHER

By W. G. SMITH, B.Sc., Ph.D.

The commoner heather is the Ling (*Calluna vulgaris*), but in ordinary usage two other species are included: Purple Bell Heath (*Erica cinerea*) and Pink Bell Heath (*E. tetralix*). These, with the nearly related genus Vaccinium, including Blaeberry and Cranberry, and in the north of Scotland, Bearberry (*Arctostaphylos*), belong to the order Ericaceæ, and together form a type of vegetation spread widely over poor and peaty soils in Britain and Ireland. Land covered with heather has long been recognized as an important asset of the poorer regions which, because of climate and situation, or for economic reasons, have been left uncultivated and unforested. Such lands, from sea-level to considerable altitudes on the mountains, are largely used as sheep-grazings, and in earlier times they were grazed by cattle more than at present. In recent times their value has increased by reason of the rents obtained from grouse shootings and deer forests. This revenue may be additional to that obtained from grazing, so that in considering the utilization of such land it is necessary to keep in view both grazing and game-preservation.

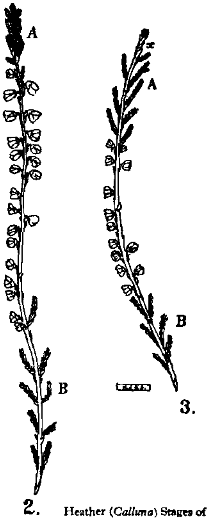
Ling or heather (*Calluna*), though widely distributed in Britain, is found in quantity in Europe only in countries adjacent to the Atlantic and North Sea, from Brittany in France to Scandinavia. In Britain it occurs on many kinds of soil, including peat, sand, and boulder clay. The chief character of a heather soil is its poverty, at least on the surface, and the plant is soon replaced by grasses, &c., where animal manure is abundant or lime is applied, or where irrigated with hard spring water. The larger areas of pure heather occur in the eastern counties of Scotland and northern England. A marked decrease in heather moors occurs west of a line from about Perth to Inverness in the Highlands, and on the western side of the Pennines, though there is a large area in Galloway, south-west England, and in Ireland. Heather is not an important plant towards the summits of the higher hills; in central Perth-

shire and adjoining counties it is replaced, mainly by Blaeberry, at about 2000 ft. altitude.

A typical heather moor is uniformly covered with heather, like a dwarf evergreen forest, occupying the land so closely that few other plants survive in the shade below. This close canopy of Ling occurs on two types of soil distinguished by shepherds and keepers: on peat partially drained by streams or artificially—moss or peat heather; on poor rocky soils with a shallow surface layer of humus—hard land. The Pink Bell Heath frequently accompanies Ling on the wetter moss land, while the Purple Bell Heath is often abundant on the drier hard land, e.g. Aberdeenshire and Galloway. Moors seem to change little from year to year, yet the ling and the bell heaths are short-lived and die away, being replaced by young plants, or failing these by other plants, including Blaeberry, Crowberry, moor grasses, Bracken, and trees. Where heather is utilized for stock or game, heather-burning is required to retain it in the best condition. The object of burning is to maintain a vigorous growth of fresh green shoots, without which the heather has a low feeding value.

The flowers of Ling are borne on short spurs on the younger branches, the new wood being formed the previous year. The formation of flower-buds depends therefore on the previous year. Each flower consists of eight coloured parts forming a perianth, eight stamens for pollen, and a central ovary that becomes the seed capsule. The flowers open in August in a favourable year, and are cross-pollinated by bees and other short-tongued insects. The ripening of seeds depends much on early flowering and a fairly dry autumn. The mature seeds are minute, oblong, and flattened, with a reddish brown rough coat. Many seeds are produced in each capsule, which is further protected by a tough whitish covering, the remains of the perianth. The seeds begin to ripen about October, some are shed then, but unopened capsules may be found through the winter. The seeds shaken out of the opened capsules germinate as autumn seedlings, or in mild weather early in the year (spring seedlings), and many seeds remain dormant in the fibrous soil. The small solid seeds are probably not carried far from the parent plant, but the capsules enclosed in their grey covering are carried long distances by wind and over snow, many of them still containing seed. The seeds are eaten by grouse and other moor birds, as shown by examination of droppings, and in this way a wide dispersal is possible.

Seedling plants have a distinct tap-root with several lateral roots growing out horizontally, thus forming a young root system not too easy to uproot. The early growth of the shoot is slow. It begins with a pair of small thickened oval seed-leaves, then follows an erect shoot bearing four to ten pairs of closely crowded needles. At about six months the seedling may be about an inch high, though the rate of growth varies according to soil. Tall-growing heather continues to form long leader



Heather (*Calluna*) Stages of Growth

1. Flowering branch, end of August, showing growth of 1914–5. A, Spur-shoot above the flowering spray (1915); B, *Spring-formed leafy spurs (1915) below* the flowering spray; C downwards to D, Part of branch which carried spur-shoots in autumn (1914) and elongated in spring (1915); E, Autumn-formed (1914) leafy spurs, elongated (1915); F, Position of flowering spray (1914); G, Upper pair of leafy spurs (1914), corresponding in position to B (1915), and showing leaves of different ages from spring (1914) onwards.

2 *and* 3. *Fruiting branches, end of* December. Letters as in 1. Note stages of advance at A since August (1); in (3) the terminal bud (x) has been bitten off.

shoots for many years, but on hard soils the leader cannot be distinguished from the lateral branches after the third or fourth year, and the result is a low-spreading type of heather. Flowering begins on the leader shoot, but in later years it also occurs on lateral branches. The new growth of a season begins from a bud at the tip of a flowering branch and may proceed during winter.

The renewal of heather by basal shoots occurs when it has been burned or closely grazed when young, and is more frequent on the softer mossy soils than on the hard ones. The shoots spring from the base of the burned stems, on or just below the surface of the soil, and on favourable soils heather burned in March may carry numerous basal shoots by autumn. They form close tufts on the old root-stocks, hence are not so easily uprooted by sheep as young seedlings.

The feeding value of heather depends on abundance of fresh green shoots, the food of sheep and grouse. When these are no longer produced freely the heather becomes " grey " and is ready to burn. Greyness is generally found on flat bushy plants, often with long bare stems (" legginess "), and the flowering shoots carry few flowers. The bushy growth may also be seen on heather heavily grazed, but a grazed plant shows abundance of green twigs and the growth is near the ground. The age at which heather may be called old varies from soil to soil. Plants from seedlings or root shoots begin to flower in a few years, and continue to produce new leafy and flowering branches every year until a time is reached when they lose their vigour. Under favourable conditions on mossy soils, there may be vigorous growth the first year and abundant flowering in three or four years, but on hard land there may be little growth in ten years. Fifteen to twenty years may be taken as an average length of life where the heather forms a cover within two or three years after burning. Heather thirty years old is probably always aged and grey, unless it has been regularly and severely grazed down by sheep. Height is not a satisfactory standard for judging when heather is ready to burn. As a rule all tall heather needs burning, but on hard and dry soils heather may be aged when it is less than 1 ft. high, whereas on peaty soils it may be 2 ft. high and still vigorous.

Assuming that heather is past its best in twenty years, then at least a twentieth of the heather on any moor should be burned each year, and any deficiency due to a wet spring should be made up in the more favourable years. The burning may be done in strips, patches, or large blocks. The shepherd, as a rule, burns large blocks of several acres, whereas the gamekeeper prefers smaller strips and patches scattered over the moors. A rotation is necessary, since burning is intended to provide a continuous supply of fresh herbage, and this can only be provided by heather of different ages. Much depends on whether the heather returns slowly or quickly. To burn a whole sheep hirsel in

one year is bad practice, because for that year at least the sheep will be without heather, and for several years they may do much damage by uprooting young seedlings. Similarly with game, a block of moor will give better results if there is young heather of various ages, as well as older heather for nesting in, for shelter and feeding during snowstorms. The adjustment of heather-burning to get the best results must always be determined by local conditions. During recent years, and especially since the findings of the Grouse Disease Committee became known, there has been a general adoption of shorter rotations, and a considerable improvement in the management of heather moors in Scotland and northern England. The above committee's publication[1] contains suggestions for heather-burning as a means of keeping grouse in health. In breaking up an area of old heather, burn it in strips about 50 yd. wide, so as to break it up for future treatment. Quick-returning heather is burnt in patches of $\frac{1}{4}$ to $\frac{1}{2}$ ac., with a fifteen-years rotation. Wet peat-moss or flow-ground is burned in large blocks up to 10 ac., with a six- to ten-years rotation, partly because this heather returns quickly, partly because it cannot be burned every year because of weather. Slow-returning " scroggy " heather on hard land is better burned in small patches; later, when the new heather will carry fire, burn again with the wind so that the fire will travel fast and only singe the heather; the object is to encourage young growth from the old root-stocks. Where grass and bent predominate the muir-burning is done every two to four years.

The time for heather-burning is during the winter or spring when there are no nests and the herbage is dry enough. Autumn burning may take place on high-lying grassy moors, but on grouse moors little of this is done. In practice most of the burning is limited to late in March or to April. As nesting begins in April on the lower moors, it has been necessary to restrict the free period for muir-burning in Scotland between 1st November and 11th April. There is, however, an extended period till 25th April, during which proprietors may burn high and wet moorlands or authorize their tenants to do so. The Act is administered through the Board or Ministry of Agriculture for the respective countries, and in cases of doubt reference should be made there.

The heather is fired with a stick carrying a bundle of wool dipped in paraffin or with a special heather-burning lamp burning paraffin; thus the whole margin of the patch or strip is lighted rapidly. A steady, not too strong wind is preferred. If the fire carries with the wind it travels fast, and with the old heather may leave a crop of partially burned stems which are objectionable where sheep graze. When burned against the wind, the heather must be drier, and burns slowly and more completely. It is necessary to control the fire, and this is done by beaters arranged along each side of a strip. Each beater is provided with a large broom

[1] *The Grouse in Health and Disease*, Popular Edition, 1912.

consisting of birch branches tied with wire so as to form a flat head, 2 to 3 ft. wide and about 4 ft. long, with a long 8 ft. shaft. It is better for the beaters to work in couples, the first broom to flatten out the fire, and the second immediately on the top of this to extinguish it. With little wind two beaters on each side of a strip may be sufficient, but as the work is severe, and there is always a risk of the fire breaking away, a larger staff is preferable. There is also a risk of the fire breaking out again on burned places from smouldering sheep-droppings or tufts of close mossy herbage. An experienced burner shows considerable skill in selecting the best direction to burn, and in utilizing walls, sheep-drains, paths, &c., as aids in limiting the extension of the fire. The management of heather and moors is thus to be regarded as a skilled craft of the country, and success or failure depends much on the individual concerned.

MISCELLANEOUS CROPS

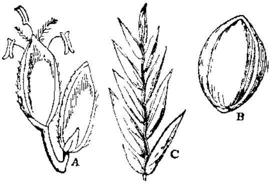
By W. G. SMITH, B.Sc., Ph.D.

Millet

The millets, along with sorghum, occupy an important place in the husbandry of all the warmer regions of the world. They hold, in countries where maize, rice, and subtropical wheats are the dominant cereals, the place of Timothy, Ryegrass, and other hay grasses in cooler climates. Along with the leguminous pulse crops they provide the subsidiary grain and forage crops of tropical and subtropical lands. The millets are grown to some extent for grain, but they play a more important part as forage and hay grasses. Their history is as old as that of wheat, and millet is recorded as one of the five plants sown each year in ceremonial festival in China since 2700 B.C. Millet grains have been found in old deposits, even so ancient as the Swiss lake dwellings of the Stone Age.

The country of origin can only be guessed at, though there is evidence that several species of millet were cultivated in China and the East, probably also in Africa, before they were introduced into Europe. As with wheat and other old cereals, numerous varieties have arisen, some of which were brought into Europe by early travellers from the East. In more recent times these have been carried by colonists to all the warmer countries, such as America and Australia, where certain of the varieties have become important crops. The wide distribution of the millets has produced a host of native names in Africa and the East, as well as numerous trade names in Europe and America. This, combined with the widely different appearance of varieties, has rendered the classification of the millets by European botanists a difficult task: for example, Italian Millet was placed by Linnæus in the genus *Panicum*, later it appears as *Setaria*, and more recently in American literature it is named *Chætochloa italica* of Scribner.

The millets and sorghum may be placed together in a series, Panicaceæ, including mainly grasses of warmer climates, in contrast to the series Poaceæ, which may be roughly defined as the grasses of temperate climates. The two groups differ in general appearance in the flowering stage, and especially in the shape of the grain. The long-grooved grain of oat, Ryegrass, and Cocksfoot is the commoner British type, while the millet type of grain, as in Timothy Grass, is rarer. The millets have always the short rounded grain broad from side to side and sometimes flattened from back to front (see figure). Each flower group or spikelet in an ear is short and matures only one grain, and there is usually a second floret, barren or with stamens only, closely attached to the grain-bearing floret. This is also the case in our native Bent (*Agrostis*), Pluffgrass (*Holcus*), Timothy (*Phleum*), and Reed Canary Grass (*Phalaris*), but the commoner British grasses have several mature grains in each flower group, so that the spikelets are several times longer than broad. The commoner millets shed the grain enclosed in two thick chaffs, and thus differ from maize and sorghum, where the enclosing chaffs are thin, membranous and lost in threshing. The ear of the millets varies from a simple spiked form (like Timothy or Foxtail Grass) to open complex ears branching like the oat.



Millet

A, Millet spikelet. The grain-forming floret has stigma and stamens, the lower floret is barren; B, Grain of Italian Millet with adherent chaffs; C, Spikelet of Tall Fescue with six grain-forming florets.

The cultivation of millets in Britain and north-western Europe is largely experimental, and the crop is rarely seen even in warmer parts like south-eastern England. In southern Europe, in countries round the Mediterranean, the millets become of economic importance and the cooked grain is used for human food, or raw grain as food for live stock, poultry, and cage birds. The United States use millet grain for stock feeding, in recent years to the value of two millions sterling, and large acreages of millets and sorghum are grown for coarse forage, useful for soiling or silage. In Canada they are less important, except as catch crops. The millets become staple crops in countries like India and China, and by selection of varieties almost any soil and any season, rainy or dry, can be suited. These crops have thus a special interest for the colonist in warmer countries, and at the present time numerous experiments are in progress to ascertain the value of varieties, for example in America and Australia.

The following are examples of the more important millets.

Common Millet of Europe (*Panicum miliaceum*, Linn.), Proso or Hog Millet in the United States and Canada. This is an annual grass, 2 to 4 ft. high, with branching ears which may be compact or open, erect or drooping. The open drooping forms are known as Broom Corn Millets in North America, from their resemblance to the true Broom Corn (see "Sorghum"). This millet has been cultivated in Europe since prehistoric times and was an important poor man's corn, the best of the common millets for grain, in countries adjoining the Mediterranean and Black Sea, but is now largely replaced by maize and potato. In India and the Far East the grain is still used cooked whole like rice, or bruised for use as a pudding or porridge. The grains of Common Millet may sometimes be found in bird-seed mixtures; they are larger than those of Italian Millet, being about ⅛ in. long, shiny, somewhat flattened, with the outer side more convex than the inner. The colour of the grain may be white, grey, yellow, reddish, or black according to variety. A bushel of grain may weigh 60 lb. Introduced into America, it is cultivated mainly as a forage crop. The hay is nutritious if cut early, but soon becomes coarse. When sown for hay in Canada, 30 lb. of seed are required per acre, but when sown for seed 20 lb. produces larger plants.

Farmyard Millet or *Grass* (*Panicum* or *Echinochloa crus-galli*). The grain-producing varieties are sometimes grouped as *Panicum frumentaceum.* This is an annual and may become a weed in arable land or waste places in Europe, but is merely a casual in Britain. It is a smaller plant than Common Millet. In India during the rainy season it grows quicker than any other millet, sometimes harvested in six weeks, and yielding up to 500 lb. grain per acre and 1500 lb. straw. Introduced into North America, it has become an established weed known as Barnyard or Cockspur Grass, and is grown to some extent as coarse forage, but as it needs moisture and good soil it has not proved itself so useful as the finer hay grasses grown on good land. As a coarse grass it requires to be cut early for hay.

Guinea Grass (*Panicum maximum*), a native of Africa, is now widely grown in tropical countries for forage. It grows about 8 ft. high, and yields several cuttings each year in a suitable climate. In India on sandy soils it is propagated by cuttings.

Italian Millet (*Setaria* or *Chætochloa italica*). The varieties of this differ considerably in appearance, and in North America, Foxtail Millet, Hungarian Grass or Millet, Japanese Millet are trade names. In India it is known as Kangu and other local names. The crop is a very old one in China, and it is still extensively grown in Central Asia, Northern China, and the Far East, being used in many parts for human food, mainly as a porridge. Recent reports give the Japanese crop yield as 10,000,000 bus. of grain. This millet is an annual, 2 to 4 ft. high. It differs from Common Millet in having a more compact head, more or less spike-like; they are sometimes seen where bird-seed and poultry foods are

sold. Introduced in bird-seed, or from cleanings of clover and grass seeds, the plant is occasionally seen as a weed in Britain. The variety known as Hungarian Grass in the United States has a simple spike-like head or ear not unlike the Foxtail Grass of Europe; other varieties have the head larger and made up of numerous compact groups of florets. Each floret produces a single mature grain and bears a tuft of bristles which give the heads a reddish or purple furry appearance. The numerous varieties differ in size and shape of ear, and in the colour of the grain ranging from yellow to red and grey to black. These varieties in America are known under many names—Foxtail Millet, Golden Wonder Millet, &c. The grain is smaller than Common Millet, with one side almost flat; a bushel weighs about 48 lb., and about 30 lb. per acre are sown for hay. The commercial seed is often variously coloured in the same sample, and work at the experimental stations includes the separation of pure strains. Hungarian Grass is grown in the United States on over a million acres, with a yield of about 1½ tons of hay per acre. This is best cut when the grass is in bloom, mainly because then the bristles of the flower heads are soft. Stock thrive on the hay, but sometimes digestive troubles arise from the hardened bristles on over-ripe ears. This grass is also used for pasture, and requires early grazing before it becomes coarse.

Green Millet (*Setaria viridis*), cultivated as a grass in southern Europe, is regarded by some as the parent form of Italian Millet.

Pearl Millet (*Pennisetum typhoideum*) is native in tropical Africa, and has been tested in Canada and Britain. In Wales in 1920 and 1921, both this and Elephant Grass (*P. purpureum*) failed to grow out of doors though they flowered under glass. Under favourable climatic conditions, in India and Africa, and on rich alluvial soils, Pearl Millet grows like maize from 6 to 12 ft. high, and is regarded as an important source of fodder.

Sorghum

The name Sorghum includes a group of grasses and cereals allied to maize and millet, which are of widespread importance in tropical and sub-tropical agriculture. The plant has been cultivated for centuries, probably not so long as wheat in Europe, but it was known to the ancient Egyptians, and in India and China early in, if not before, the Christian era. Like all ancient cereals the orgin is obscure, and cultivation in many lands has led to the evolution of numerous varieties or races, adapted to different types of agriculture, so that few plants surpass sorghum in its utility to man.

The different sorghums found in cultivation are probably all derived from Aleppo Grass, *Andropogon halepensis* of Brotero, originally placed

by Linnæus in the genus *Holcus*, and later by Persoon under *Sorghum*. Earlier authors grouped the perennial grass or forage forms as *Andropogon* or *Sorghum halepense*, while the annual grain-bearing forms were grouped as *Andropogon sorghum* or *Sorghum vulgare*, but modern authors tend to regard the two groups as sub-species of a single species.

The following classification of the commoner sorghums grown in the United States indicates their many uses.

I. ANNUAL SPECIES.	
A. Pith juicy.	
(1) Juice abundant and sweet; source of sugar and syrup	Sorgo.
(2) Juice scanty; grain and forage crops in Africa and India	Kafir Corn.
B. Pith dry.	
(1) Ears compact, 4 to 10 in. long:	
(*a*) Grains flattened with grey or greenish chaff; grain, &c., Egypt	Durra.
(*b*) Grains rounded with brown or black chaff; grain, &c.	Milo.
(2) Ears lax, 10 to 25 in. long:	
(*a*) Branches greatly elongated; switch brooms and grain	Broom Corn.
(*b*) Annual grasses and forage plants	Sudan or Tunis Grass
II. PERENNIAL SPECIES.	
Grass and forage plant	Johnson Grass.

A scrutiny of this table shows a wide variation in the form of the ears or panicles, from short to long and from compact to lax. The colour and shape of the grain vary quite as much, from nearly white to black. The connecting link is that the structure of the spikelets and florets remains constant (see figure). Each spikelet consists of a single grain-forming floret and a barren one, with or without stamens, attached by a short stalk. The spikelets are grouped into large complex panicles sometimes closely crowded, or in the Broom Corn and forage varieties forming small clusters on long spreading branches; the Kafir Corn types are intermediate. The grain is large for a grass, but smaller than maize, about ⅛ in. long and nearly as broad, flattened or egg-shaped, sometimes rather triangular. The colour of the grain in most sugar varieties varies from yellow to red or black, and the grain remains enclosed in the chaff till threshed out. In other varieties the grain is light coloured and falls naturally out of the chaffs. As with maize, the growth of sorghum consists mainly of the first shoot, and tillers occur only to a slight extent.

The utilization of sorghum for grain, sugar, forage, and broom-making increases its economic possibilities to an indefinite degree. Selection of varieties opens the way to cultivation in any climate, except the colder lands, hence in the development of warm and tropical countries sorghum is one of the most important of crops. In Egypt and northern Africa the name Durra or Dari, with local variants, is given to the grain varieties, and they form an important human food. In South Africa the crop is known as Kafir Corn, as distinct from maize or mealies, but the natives distinguish grain-bearing varieties (Ama-Bele in Zulu) from the sugar or Shaloo (Im-Fe), while the perennial Johnson Grass and the annual Sudan Grass are important forage plants. In India sorghum (Jowar or Juar) fills an important place as seasonal crops; thus in some districts the autumn forms have compact heads with rounded grains, and the spring varieties are generally lax in the ear, with elongated grains, and stems with sugary juice. In Europe the distribution of sorghum is limited because it is sensitive to frost and cannot be sown in Central Europe before May. In the Hungarian plains quick-ripening varieties require five months at least to ripen seed, hence in South Germany the plant may flower but does not ripen seed. Seed production is limited to favourable climates in southern Europe, but as a forage plant sorghum can be grown and cut green, like maize. In England it is almost entirely an experimental plant. Recent experiments at Chelmsford, Essex, gave about 20 tons per acre of green fodder, varying more or less according to variety. Experiments in 1921 at Aberystwyth, Wales, with several varieties showed that growth began too late to be useful. In North America about three-fourths of the sorghum crop is used for forage or silage. The crop is more adapted to the southern cotton states, but it has also proved useful in the drier western states, where

Sorghum

A, Flowering stem with leaves and floral branches; B, Spikelet with two florets: grain-forming shows two stigmas and awn; the barren floret with short stalk; C, Barren floret, showing stamens; D, Grain.

the crop started in a wet season continues to yield forage well into the dry season. For silage, sorghum compares favourably with maize.

Grain Sorghums.—The food value of the grain lies mainly in the soluble carbohydrates, while in nitrogen, oil, fibre, and ash the analysis follows that of maize. The recently published *Rations for Livestock* gives the following digestive nutrients for Dari (Durra) compared with other poultry foods.

	Dari.	Maize.	Barley.	Wheat.
Proteid	7·7	7·1	6·5	10·2
Oil	3·0	3·9	1·2	1·2
Soluble carbohydrates	60·5	65·7	62·2	63·5
Nutritive ratio ..	1:9	1:11	1:10	1:7
Maize meal equivalent	91	100	85	88

On this basis, 91 lb. of maize is of the same productive value as 100 lb. of Dari.

The grain yield is high in suitable climates, but not in Europe except in the south. Recent experiments in France gave a crop of about 10 oz. of grain per plant in south France, but less than half of this in Paris. In the United States, chiefly in the south, the crop of Kafir and Milo was about 17,000,000 bus. (1909) of grain, but much more is grown for forage. The quantity grown in Africa, India, and China is very large but it is mostly used locally. A considerable amount finds its way into poultry foods in Europe, either as flattened rounded whitish grains (Durra) or as coloured shining grains (Sugar Sorghum). The cultivation may be primitive as in South and Central Africa, where cleared veld or bush is roughly tilled, and after some crops of Kafir Corn and Maize have been secured the land is abandoned. In the Sudan Nile region Durra is sown with or without Sesame, an oil seed, for four or five years, then Gum Acacia for about ten years, followed by five years Durra, and so on. The gum is an important source of revenue; the Durra and Sesame are mainly consumed locally. In India many distinct varieties are grown, and as a proof of antiquity it has been pointed out (Sir George Watt) that the autumn and spring crops are not interchangeable either in season or soil, but to ensure a full crop the proper variety must be used. One system of cultivation in India includes preparation of the land, the sowing of 6 to 8 lb. of seed per acre in drills, and thinning of plants to about 1 ft. apart.

Sugar Sorghums.—The varieties with a juicy pith are utilized to some extent as a source of sugar or syrup. Thus in the United States, in 1909, about 16,500,000 gall. of sorghum sugar were produced; yields of 1000 lb.

molasses per acre have been obtained. The sugary juice is used largely locally, either directly or as a source of alcohol. The possibilities as a sugar crop have been examined in recent years, generally with unsatisfactory results. In India Sweet Jowar gave a small yield of sugar and the taste was peculiar. As a "war sugar" experiment in the south of France, Sweet Sorghum stems gave 60 per cent of juice, with a yield of 10 to 16 per cent of sugar, compared with 16 to 18 per cent for sugar-cane, and about 18 per cent for sugar beet. The sorghum-cane juice differed from sugar-cane juice in the high proportion of non-crystallizable sugars. The syrup could be used for alcohol production, and with a crop of 15 tons per acre a yield of 180 gall. of spirit was obtained at a cost of production less than a sugar beet crop.

Broom Sorghum.—An interesting product of sorghum is the manufacture of brooms from the branches of the open-panicle varieties. The common carpet switch or broom made of tough straw-like material is largely a product of sorghum, though sometimes called a rice broom. These were made originally in Italy and Hungary, but the industry has extended to other lands, including America and Australia. The finer branches of the panicle are used. These include shorter branches, 15 in. long, used for insides of brooms, longer branches, 17 to 20 in., used for "cover", while the outside of the broom is made from "hurl", fine straight branches 20 to 25 in. long. An ordinary broom requires about 1½ lb. of brush, about one-third of each grade. The return from the crop is higher than that of maize when prices for brush material are favourable. Deep well-drained alluvial soils give the best return, but where climate is suitable lighter soils may be utilized. The crop is sown from seed after there is no risk of frost, in furrows about 3 ft. apart, the seedlings being thinned to about 4 in. apart. When the heads are formed there is a risk of the branches becoming spread out and bent; to avoid this the heads are bent over till they hang downwards, thus securing straighter brush. Experience is required as to time of harvesting to obtain a uniformly coloured brush, greenish or golden, and not brittle from over-ripening. Yields of half a ton or more per acre of clean brush are obtainable. The seed, about 25 bus., is not properly matured but has a secondary value for stock-feeding. The stalks and leaves furnish a coarse forage or are ploughed into the soil.

Forage Sorghums.—These include the perennial Johnson Grass, the annual Sudan or Tunis Grass, and crops of Kafir Corn, Sweet Sorghum, and other varieties. The value of sorghum arises from its rapid growth under suitable climatic conditions, and the herbage being rich in sugars is easily assimilated by stock. This is best secured by early cutting. In all sorghum-growing countries a considerable part of the crop is used for forage, and in the United States about three-fourths of the crop is used for hay, green soiling, or silage. The produce compares with green

maize, though in cooler countries like the United States and southern Europe it is regarded as inferior both in quantity and quality. Aleppo or Johnson Grass, the perennial form, occurs along the Mediterranean coasts of southern Europe and Africa, southwards through the Sudan and Senegal to South Africa, thence through southern Asia to China. As an introduced plant it is cultivated in Australia and North and South America, where it has become a perennial weed. In England and central Europe it can only be cultivated to a limited extent because the young spring growth is sensitive to frost. Under suitable climatic conditions, and with moist soils, Aleppo Grass may reach 6 ft. high and yield several crops. The forage is comparable with Cocksfoot Grass, if cut early enough; the hay is relished by stock and they thrive on it. American analyses place the feeding value higher than Timothy hay. A serious objection to the perennial forms is the creeping root-stocks, much like our native Couch Grass, which are difficult to eradicate from arable land. In recent years attention has been given to the varieties known as Sudan or Tunis Grass, which have not the creeping rootstocks and can be grown as annuals. The grassy forms of sorghum have considerable possibilities as forage crops in climates where early growth is favoured by warmth and moisture. In some of the drier states of North America it has been claimed that Aleppo Grass is the most drought resistant of the useful grasses.

Poisoning of stock has been reported from various countries where the sugar and grain sorghums have been used in the young state for stock-feeding. Sorghum contains compounds which under certain conditions break up and liberate the poisonous hydrocyanic acid. Similar poisons are known in Cherry Laurel, Oil of Almonds, and in other species of *Prunus*. Rapid death of cattle has been observed after feeding on green sorghum, but the evidence indicates that his effect is not so marked later in the growth. There seem also to be considerable differences in the varieties grown, for in India and other countries Sweet Sorghum is much used for forage.

Leguminous Plants

The value of leguminous plants as forage and as improvers of the soil has long been recognized, and many trials have been made to utilize promising species. Plants of this order occur often on poor soils, where the power of fixing free nitrogen by the root tubercles assures them of the important nitrogenous food item so important for plant growth. Some are deep-rooted perennials adapted for growth in deep soils liable to drought, others are annuals with prolific seed production, so that after drought or winter they come up year after year. The success of Red

Clover after its introduction into England about 1650 brought the value of leguminous crops into prominence, and during the following two centuries others were tried. Lawson's Catalogue of 1852 describes over fifty species of Leguminosæ tested by that firm, often as forage plants. The more important are dealt with in the special articles. This part refers briefly to subsidiary or less-known species, many of no great importance at present, but, in view of increased demand for forage and silage crops, it may repay to reconsider their value. Especially with increased knowledge of plant breeding, it should be possible to raise varieties better adapted to special soils and climates, a process which has led to great results in connection with Alfalfa or Lucerne in America. The outstanding merits of Wild White Clover, a selected strain of white or creeping clover, and recent work on Red Clover make a hopeful beginning for Britain. The plant breeding stations recently established and the renewed activity of commercial firms indicate a new era, and the selection of improved strains of leguminous plants offers a promising field.

The following leguminous plants appear worthy of attention:

I. Species with leaves divided into pairs of leaflets, and ending in tendrils.

Vetches.

Vetches (*Vicia*) having tendrils and two to many pairs of leaflets. Some species are climbers (Tares and Vetches), others are more erect like the bean. Rapid growth and heavy yield render some of the species promising forage crops, equal to or better than those now in use.

Siberian or Hairy Vetch (*Vicia villosa*) recalls in its foliage and deep blue flowers the Tufted Vetch (*V. cracca*) of our hedgerows, but the Hairy Vetch is covered with soft hairs and is a winter-annual, sown one year, fruiting the next. Lawson (1852) recommended this vetch for yield and as relished by cattle. Within the last few years, in Salop (England) and in Wales, heavy crops have been obtained as well as seed. Sown between midsummer and September it makes a strong growth for forage up till Christmas, is hardier than Common Vetch in winter, and makes an earlier growth in spring. When sown in spring it seeds about August and yields a heavy aftermath.[1] As this vetch is liable to lodge, it is recommended to sow it with a stiffer plant (e.g. Rye or Sweet Melilot). In Canada it is mainly sown in orchards as a cover crop, and in southern Ontario it stands the winter if sown early enough.

Bush Vetch (*V. sepium*), a common British wild plant with a low straggling growth and blotched purple flowers. It was recorded by Sinclair as a useful pasture plant, and in 1921 was strongly recommended by Brown. A perennial with deep roots, it is sought out and eaten by cattle in pastures, evidently with relish. Grown as a crop it yields

[1] Brown, *Jour. Min. Agric.*, April, 1921.

a heavy forage and would fill a place in land where it could be left for several years; at present the seed is difficult to obtain, and the crop does not set seed well, nor is it easily harvested as the pods ripen irregularly and burst.

Narbonne Vetch (*V. narbonnensis*) is a broad-leaved half erect species, a bean in habit rather than a vetch. It is native in France, cultivated there, but according to Brown (1921) it is not very hardy in this country.

Vetchlings.

Vetchlings (*Lathyrus*), climbing or scrambling plants with tendrils, leaves reduced to one or a few pairs of leaflets (fewer than vetches), and stems winged or flattened as in the Sweet Pea. This group has been recommended from time to time because of their prolific growth, but the reports are not so favourable as those for true vetches; they are not so readily eaten by stock and are suspected of poisonous qualities.

Narrow-leaved or Flat Pea (*Lathyrus silvestris*) is a perennial with a strong root-stock; the stems are tall, up to 5 ft., and climbing. The flowers are dark rose-coloured, resembling a small Sweet Pea; seeds with difficulty. The plant requires deep soils, not necessarily rich, and resists drought. Its value as a forage plant is doubtful as the wild plant is bitter, but selected cultivated strains are said to produce better fodder. A recent report (Harper Adams College, 1912) gives a yield of over 10 tons per acre, but the produce was hard, coarse, and not relished by stock.

Everlasting Sweet Pea (*L. latifolius*), the garden perennial, has also been tested, with unsatisfactory results.

Grass Pea or Chickling Vetch (*L. sativus*) is an old French crop, grown to some extent in Canada, but rarely tested in Britain. The plant is annual, grows to 3 ft., and provides a fair crop of useful forage. The name Chick Pea is sometimes given to this and to the Flat-podded Vetch (*L. cicera*), sometimes grown as a forage crop in France, but the true Chick Pea or Gram (*Cicer arietinum*) is a plant of warmer countries, southern Europe, India, and United States, grown partly for fodder but mainly for the large seeds.

II. Species with leaves of three leaflets—no tendrils.

(*a*) Clovers (*Trifolium*) with flowers in a dense head, and the fruit or small pod enclosed in the withered flower parts.

(*b*) Lucernes and Medicks (*Medicago*), heads more or less clover-like, but the pods curved or twisted into spirals and not enclosed in the withered flower parts.

(*c*) Sweet Clovers or Melilots (*Melilotus*), scented plants with flowers in elongated clusters or racemes, fruit with one to three seeds, not opening.

Lucernes and Medicks, conveniently grouped as perennials, with the lucerne habit of growth.

Yellow Lucerne (*Medicago falcata*, varieties or hybrids), distinguished from the purple-flowered Alfalfa Lucerne by the flower colour. In the search for varieties of Lucerne suitable for the various climates of North and South America and other countries, the merits of a number of allied species and varieties have been tested. Lawson (1852) described Yellow Lucerne, a plant wild in Europe and cultivated in mountainous parts of Switzerland and France. It is upright, rather woody in growth, has bright yellow flowers, and pods sickle-shaped. Recent reports are not too favourable in comparison with true Lucerne. The crop though heavy tends to lie down, yields rather low, and ripens seeds sparingly.

Several varieties known as Variegated Lucernes, including Grimm's Alfalfa, are regarded as hybrids between the yellow and the purple Lucernes, with flowers mixed in colour. At present there is a lack of uniformity in the seed, but races hardier than Alfalfa are being tested. Canadian experiments over nine years show larger hay yield (3 to $3\frac{3}{4}$ tons) from the variegated strains, and these promise well for colder countries.

Yellow Trefoil or Black Medick (*M. lupulina*) is included in seeds mixtures in Britain as an annual or biennial. It is a useful plant that survives on droughted soils, useful for sheep-grazing but scarcely to be regarded as a forage crop.

Several other annual Medicks occur as casual field weeds. The fruits or pods are conspicuous, being fairly large, twisted spirally, and often spiny. These fruits are introduced frequently with foreign barley used in maltings, and as " burrs " in foreign wool. From time to time species have been tested as forage crops, but they are suitable only in the warmer parts and the burrs are a distinct objection to their extended use.

Sweet Clovers or Melilots are distinguished by the fragrant smell, recalling that of Sweet Vernal Grass and Woodruff. White- and yellow-flowered species are found occasionally in hay seeds or about field margins. The flowers are recognized by bee-keepers as a valuable source of honey.

Bokhara or Biennial White Sweet Clover (*Melilotus alba*, var.) was introduced into Britain about 1840 and attracted attention under the name Tree Clover. Lawson (1852) refers to plants grown in their experimental ground 12 to 18 ft. high. At present it is receiving attention in Canada, Australia, &c., as a forage crop for cattle, providing a succulent fodder if cut young, but becoming harder later. The early growth is slow and yields poorly the first year, but in the second year growth is rapid, the stems tend to become woody, and the leaves and seeds shatter so much that most of them are left in the land. Crops of 1 to $2\frac{1}{2}$ tons of hay are given where lime and fertilizers are used. Canadian reports

state that stock refuse to eat the crop, and cows fed on Sweet Clover yield milk with a peculiar flavour.

Annual White Sweet or Hubam Clover is an annual variety of the above which at present is being tested as a suitable forage plant for parts of the United States. Tested in Wales in 1921, it grew slowly, required a long growing season, and gave plants about 4 ft. high, but deficient in leafage.

Yellow Sweet Clovers (*M. officinalis*). Annual and biennial varieties tested in the United States and in Canada yielded smaller crops than the white varieties, and are not recommended as forage crops though they may have some value in pastures.

III. Leaves with two or more pairs of leaflets and a terminal leaflet, no tendrils.

Serradella (*Ornithopus sativus*). An annual leguminous plant sometimes grown in southern England. It occurs wild in Portugal, and last century was introduced as a useful plant for dry sandy soils. It is a slender plant, 12 to 18 in. high, with rose-coloured flowers, and curved fruits that break across the pods into one-seeded joints. Sown about May, 8 lb. per acre, it may be utilized from October onwards for sheep, or for ploughing in on poor lands, so that it has no special recommendation as a bulky forage crop.

Bird's Foot Trefoil (*Lotus corniculatus*) is more of a clover pasture plant than a forage crop. It is a native perennial common on dry, short pastures and distinctly useful there. The flowers are yellow, red-tipped before opening, and both they and the dark seed-pods are arranged like a bird's claw, hence the local names such as Crow's Toes, &c. The species includes well-marked varieties, and some of these after selection may become useful forage plants on drier soils. Similarly for wet soils the Marsh Trefoil (*L. uliginosus*) offers opportunities for improvement.

Comfrey

Early in the nineteenth century attention was directed to the possibilities of Comfrey as a succulent green forage plant. It was grown in different parts of Britain and Ireland, and, in four or five cuttings each year, gave crops of 30 to 40 tons per acre of green fodder. Comfrey belongs to the order Boragineæ, of which the taller species have a rough harsh foliage, large single (not opposite) leaves, and tubular flowers arranged in a characteristic inflorescence. The fruit consists of four little nuts lying in the cup of the outer persistent part of the flower.

The Comfrey genus (*Symphytum*) includes two native species and several others occasionally found as naturalized plants. Yellow Comfrey

(*S. tuberosum*) is a yellow-flowered low (1 to 2 ft.) plant with underground tubers, found in flower in early summer in open woods or hedgerows, and not of much economic value. The taller species and varieties grow over 3 ft. in height and vary in colour from white to blue or reddish purple. The native species (*S. officinale*) has several well-marked varieties, varying in flower colour, and all are tall plants that with improvement might become useful for forage. The Comfrey recommended as a crop plant is Prickly or Russian Comfrey (*S. asperimum*), native of the Caucasus, and introduced into Britain about 1800. This has large heart-shaped leaves which, as well as the stems, are covered with stiff prickly hairs. The stem is filled with pith (not hollow), and the flowers are blue-purple. The rough foliage makes the plant unpalatable, but cattle are said to become fond of it, if cut young and tender and allowed to wither partially before using. As a silage plant it might be more acceptable to stock. The plant yields seed sparingly, and is raised more quickly if cuttings from the root-stocks are used for propagation. These are planted 2 to 3 ft. apart, with room between the rows for cleaning and cultivation. Once established it becomes a perennial crop yielding a succession of mowings each year. A rank-growing plant, it requires deep soils, heavy manuring, and should be kept free from weeds. It seems unlikely that Comfrey will be much grown as a crop, except on special pieces of land outwith the farm rotation. Voelcker's analysis of Prickly Comfrey in 1891 gives a large amount of water (90 per cent), a mucilaginous juice containing a little sugar; the nitrogenous matter is below that of leguminous crops, but the proportion of woody matter is not excessive. It is therefore rather a watery feed, somewhat equivalent to green mustard, turnip tops, or Italian Ryegrass from irrigated land.

Teasel

The heads of the Teasel, or Teazle, used in cloth finishing are obtained from a plant, the Fuller's Teasel (*Dipsacus fullonum*) of the scabious order, Dipsaceæ. This order has numerous small florets closely gathered into compact heads, not unlike the more familiar heads of thistle, daisy, dandelion, and other Compositæ. The ripened heads of the Teasel would attract attention by their long conical shape and size. These are several inches long, an inch or two wide, and distinctly prickly. The part of economic importance is not the flower proper, but a scale that arises at the base of each floret, minute in most plants with heads, except round the margin where they form the involucre or bud cover of a scabious or thistle. In the ripe teasel head each floret has a scale slightly longer than the floret, and ending in a stiff prickly point. The efficiency of the Teasel depends on these prickly points, so that heads with uniform

elastic prickles have a higher value than other heads where the prickles are brittle and less uniform.

In the finishing of cloth the heads are arranged on a revolving cylinder over which the cloth is pulled, so that the spiny scales of the Teasel heads pull up the ends of the wool fibres and produce a rough nap which later is cut and smoothed down to give the required finish. The Teasel has been used since the twelfth century at least, and, in spite of increased use of machinery in woollen manufacture, nothing has been invented to give the same result as the teasel finish.

Recent figures give the annual value of heads used in this country as £15,000, while in France, in three districts, the produce some years ago was 40,000 cwt. of heads from about 3700 ac., and valued at £50,000. The cultivation in Britain fifty years ago was distributed from Essex and Somerset northwards to Yorkshire, but in recent years it has become more restricted to the woollen districts of Yorkshire and western England. As in the case of the hop crop, seasonal variations and imports from abroad make the Teasel crop a speculative one liable to considerable fluctuations.

The cultivation of the Teasel requires special conditions as to labour and climate. The plant is a biennial, forming during the first year a broad rosette of long green leaves, and in the second year giving rise to a large branching stem, 3 to 6 ft. high, with cup-like leaves that hold water, and branches ending each in a teasel head. The seed is sown in March in wheat land and preferably after wheat. The sowing may be in a special seed-bed to be transplanted the following year, or the seed is drilled where it is to ripen. In the latter case, the land is cleaned several times during the summer and autumn, and the seedlings gradually thinned. About March in the following year, the land is cultivated and the plants are finally thinned to about 3 ft. apart, also blanks are filled up. Harvest is in August or September, and the ripe heads are collected in bundles and dried under cover. The plants are gone over several times as the heads ripen unequally. The first crop is mostly the larger terminal heads or "kings", which are somewhat coarse and rough for the finer kinds of cloth. A later collection secures the "prime heads" or "middlings", the more valuable heads. Still later the smaller late-ripening heads are taken. This method of cropping leaves a large residue of stems which are of no particular value except to burn for ash. The dried heads are still further graded by the teasel merchants to secure the uniformity so necessary in cloth finishing, and these carefully selected bundles are supplied to the manufacturer.

The crop is thus not exactly suitable for ordinary farm rotation, so that the land is either rented by the merchant, who arranges for labour, or it is done on small holdings, as in France. The crop entails considerable risk, because in winter many seedlings may be killed by frost or

damp off, and again at harvest a period of wet weather may result in badly ripened heads of low value. The best harvesting conditions will be found in the drier eastern counties of England.

The Wild Teasel (*Dipsacus sylvestris*) is a native of Britain, found here and there, sometimes in abundance. It is closely related to the Fuller's Teasel, which may be only a variety improved by long selection. The Wild Teasel is generally a smaller plant in growth, but the heads are not of commercial value as the prickly scales are not suited for cloth finishing.

Gorse, Furze, or Whin

This well-known spiny shrub has the flower and fruit characters of the order Leguminosæ, and is closely related to the spineless Broom (*Cytisus scoparius*), the two frequently growing together. The Gorse cultivated as a crop is mainly the Common Whin (*Ulex europæus*), but in considering its value for grazing animals, two other species must be mentioned. *Ulex gallii* is a smaller shrub, but may reach a few feet in height, it is distinguished by flowering in late summer and by ripening its pods in spring, and has a fairly wide distribution in Ireland and England, less so in Scotland. The third species, Petty Furze (*U. nanus*), creeps low among other herbage, rarely becoming a shrub, and, in quantity, is limited mainly to the south of England. The recognition of Gorse and Broom as fodder plants is very old, for in Scottish records of the fifteenth century these plants were recommended to be sown in order to increase the scanty winter herbage of the great wastes of that period. The crop was in use more or less until the introduction of clovers into farm rotations, and even as late as the early nineteenth century many farms had a " whin mill " for crushing Gorse and Broom for stock. At present these plants are regular crops only in some hilly parts of Britain, to some extent in Ireland, and in parts of Western Europe, especially on the coast lands of Brittany along the rocky French shores of the English Channel, where recently about 15,000 ac. were under Gorse as a crop.

The seed used is generally that of the ordinary wild spiny plant, but it seems probable that, in case of demand, the spiny character could be modified by selection. A variety, Irish Furze, originally found in County Down, attracted attention in the nineteenth century because it produced an upright shrub with a considerable amount of green soft growth; but seed is scarce and probably the plant would require to be propagated from cuttings. Another variety, French or Foxtail Furze, is also nearly spineless and is referred to later in connection with feeding value.

Gorse grows naturally over a wide range of soils, but succeeds better on light or shallow soils with a sunny exposure and liable to drought, because on these it is not so subject to competition from grass or trees

that could smother it. As a leguminous crop it would improve inferior soils, but it does not succeed on peat which has not been drained or cultivated. The plant has a wide range in Britain over the lower hilly districts, but is less common above the limits of cultivation. It is widely distributed in western France and Germany, but is rare in Scandinavia unless where planted.

When grown specially, the seed is sown from 20 to 30 lb. per acre with a corn crop as nurse; a thick seeding is necessary to prevent the plants becoming too bushy and woody. The seedlings grow slowly, bearing a few trifoliate leaves before the spiny leaves and branches are developed. Later the plant is almost leafless, and the tender green branches provide the fodder. Cutting begins when the crop is tall enough, generally in the autumn of the year after sowing. It is usual, as in Brittany, to make sowings in successive years and to cut the plots when ready, sometimes every two years. When the crop no longer produces enough young growth, it is grubbed up for fuel or burned as it stands. Gorse, like heather, has a short-lived period of usefulness, for if left without attention it grows long and bears the green growth high up beyond the reach of stock. If the bushes are burned young, under ten years, they frequently produce numerous green shoots from the base, about the soil level, and this provides good forage for grazing stock. If Whins are burned old, renewal comes only from seedlings, which spring freely on burned ground, but are smothered if grass grows strongly.

Where Gorse is used for fodder, it is cut as required, two or three days' supply at a time, and must be crushed or chopped while fresh. A special whin-mill was formerly used which cut into short lengths and also bruised the twigs, but modern chaff or straw cutters can do this sufficiently well if set to cut short. An old simple Gorse bruiser was a piece of tree butt on which the Gorse was bruised by a mallet, plane on one face, and having on the other four cutting blades arranged in a cross for cutting the stems into short pieces. As fodder, Gorse must be regarded as somewhat coarse, but various observers record that horses and milk cattle acquire the taste for it and take it readily, leaving the harder woody parts. It is best used from October to January, as after this it becomes bitter. The results of an experiment in feeding sheep are given by Voelcker from the Woburn Experimental Farm. French Spineless Gorse was sown in May, 1897, on poor soil with barley, after a poor crop of barley. The Gorse was ready for cutting in October, 1898, and during the winter yielded about 11 tons per acre. If was fed to Hampshire and Oxford cross sheep, to test how far Gorse could replace roots. There was difficulty in getting the sheep to eat enough of it, and the average consumption was about 2½ lb. per day, equal to about 6 lb. of roots. Gorse seems thus only fitted to be an additional food along with roots, hay, &c. The sheep receiving

Gorse gave favourable results as regards health and increase in live weight, and the mutton was regarded as improved in flavour. The analysis shows that this plant is drier (about 56 per cent moisture) than swedes (about 91 per cent), and contains more nitrogenous matter, soluble carbohydrates, and ash, with a large increase in woody fibre. French analysis show much the same composition, and that for feed for horses the digestibility is better than might be expected from the appearance. About 200 lb. Gorse is regarded as equal to 100 lb. hay.

Grazing stock, including sheep, make considerable use of Gorse where it occurs on pasturage, and it must be regarded as distinctly useful herbage, especially on shallow rocky soils liable to drought. It affords some shelter for sheep, and round about the bushes there is often an early growth of Yorkshire Fog (Pluffgrass) which is useful. Older bushes are rarely touched, hence they should be kept well burned to promote a growth of low fresh green shoots.

Broom is not so favourably regarded as Gorse. Sheep eat it, but scouring often results, and to sow Broom is doubtful economy except for stock accustomed to it.

Sunflower

The true Sunflower (*Helianthus annuus*), probably a native of Mexico, has long been cultivated in Russia, Southern Europe, India, and other warmer countries. The chief product is the seeds from the ripened heads, which are rich in oil, and may be used, raw or roasted, for human food (Russia), for poultry, or for oil and oil-cake. The necessity for ripening the seeds renders the rest of the plant of little value for stock. The Jerusalem Artichoke (*Helianthus tuberosus*) and some other Helianthi produce tubers like the potato, which are used for stock-feeding, and the stems and leaves cut green have been used for forage or silage. The Sunflower belongs to the order Compositæ, and the flower-heads are amongst the largest of flowers, measuring from 6 to 12 inches across. Each head bears hundreds of florets crowded closely on a flat disc, and each matured floret produces a fruit or achene, commonly known as a seed. These vary from $\frac{1}{3}$ to $\frac{1}{2}$ in. long, and are about half as broad, egg-shaped and flattened, with the outer husk or fruit wall white, black, or striped. The hard brittle husk splits along the margins, under pressure, and releases the single seed. The size of the heads and seeds has been considerably increased by selection of suitable varieties, and it is probable that other qualities, such as early ripening, could be improved by careful breeding.

The seeds are especially rich in oil, fairly high in protein, but low in carbohydrates. The following figures (*Rations for Livestock*) will serve for comparison.

	Fat.	Protein.	Soluble Carbo-hydrates.	Fibre.	Ash.
Sunflower seed ..	32·3	14·2	14·5	28·1	3·4
Sunflower cake (decorticated)	13·8	37·4	20·4	12·1	6·7
Linseed ..	36·5	24·2	22·9	5·5	3·8
Linseed meal ..	3·1	35·7	33·9	9·0	6·5
Wheat	1·9	12·1	69·0	1·9	1·7
Oatmeal	9·4	14·0	65·0	1·2	1·8

Selected varieties, after removal of the husk, may give 20 per cent of oil, and the crushed residue containing from 10 to 14 per cent of oil and 30 to 40 per cent of nitrogenous compounds is suitable for stock-feeding. The husk contains the larger amount of fibre, hence cake made from entire seeds crushed may contain up to 30 per cent fibre, whereas in decorticated cake only half of this, or less, is present.

The Sunflower crop requires deep soils in good condition, and above all, seasons suitable for ripening the heads. In the Hungarian Plains and Italy the crop is often grown in strips along with maize or vegetables. In southern Russia the average crop is given as from 6 to 18 cwt. of ripened seed per acre, with an average of about 8 cwt. Experimental work with Russian seed grown in south Italy, without manure or irrigation, gave plants 7 ft. high, heads 8 to 12 in. diameter, and a seed yield of 43 cwt. per acre (5 oz. per plant) with plants about 20 in. apart. Considerable improvement of yield was obtained by selection of the better strains, and the yield was further increased by irrigation and manuring.

The importance of Sunflower seed for poultry foods led to the encouragement of its cultivation in England in recent years, the seed of giant selected varieties being supplied through the Ministry of Agriculture. The seedlings require to be raised under glass, and are transplanted about May to deep soil in a sheltered and sunny position. About 1½ lb. of seed are needed for an acre with plants 2 to 2½ ft. apart each way. A yield of 12 cwt. per acre of fully ripened seed is regarded as a minimum crop. Where ripening is uncertain, or in an unfavourable season, the final ripening of the heads may require to be done under cover, and in the hop districts the oast kiln can be utilized. These conditions mean a cultivation in Britain limited to the warmer and more sunny parts, for though the plants flower in the northern parts in a favourable summer, they rarely produce much mature seed.

LUPINS

By A. W. OLDERSHAW, M.B.E., B.Sc.

Lupins as a farm crop are not very well known in this country. They belong to the natural order Leguminosæ, and in certain respects resemble field beans in character. No statistics exist as to the area under lupins in Great Britain, but it is estimated that there are between 1000 and 2000 ac. grown in East Suffolk annually.

There are three varieties of lupins—blue, yellow, and white. Of these the blue variety is stated to be best for seed production and the yellow for bulk of forage per acre.

Lupins are suitable for growing on very poor light land. They will even grow where the land is definitely acid as shown by the presence of sorrel and spurrey. Like other members of the leguminous family of plants, they possess the power of assimilating the free nitrogen of the air. On the poorest of light blowing sand they will grow most luxuriantly in a favourable season, often producing a dense mass of green fodder 4 or 5 ft. high. The quantity of nitrogen accumulated by this luxuriant growth is very large; the deep tap-roots of the lupins also penetrate deeply into the subsoil and open it up for succeeding crops. The consequence of this is that whether the lupins are ploughed in green, folded with sheep, or harvested, the crop following them, frequently rye, is almost certain to be good. In fact so great are the manurial properties possessed by lupin residues that it is maintained by Suffolk farmers and also by the farmers in Schouwen, at the mouth of the Scheldt, that lupins and rye can be grown alternately for an indefinite period on poor light land.

Experiments conducted many years ago by Dr. Schultz showed that by applying mineral manures—basic slag and potash—poor light land can be permanently increased in fertility by lupin cultivation and transformed into a useful light loam. Lupins have not, as a rule, been manured in this way in Suffolk, in fact they do not usually receive any manure at all in that county, so that this method of improving light land requires

further investigation in this country. However, it appears to be a most promising means of permanently improving poor light soil.

Lupins are drilled at the rate of $1\frac{3}{4}$ to 2 bus. of good seed per acre. The seed is not infrequently damaged in harvesting, and where that is the case it should be tested for germination and if necessary a larger quantity sown per acre. If it is intended to harvest the seed, it is desirable to drill not later than April or ripening may not take place properly.

Under East Anglian conditions seed drilled about the middle of April will usually be ripe by the first week in September. Lupins must not be drilled too early or the crop may be injured by frost. It is a great mistake, however, to postpone sowing unduly. If this is done the crop will ripen so late as to make harvesting a matter of great difficulty. One farmer in Suffolk whose land is near the sea, where there is not much danger from spring frosts, sows in March when he wishes to save the seed. When sown during the first week in May, however, the seed usually ripens satisfactorily in Suffolk.

In 1918 lupins sown in the middle of May did not ripen until November, and even then the seed was not properly matured and was only harvested with the greatest difficulty.

In Suffolk the crop is cut with either the binder or the back- or side-delivery reaper. When cut with the binder the spring pods rather injure the canvasses. The sheaves are shocked in the same way as are beans. If cut with the back- or side-delivery reaper the crop is allowed to dry in bundles and is harvested loose. It hangs together well when pitching, and this method of harvesting possesses the merit of not requiring any binder twine.

The crop is threshed exactly as with beans. From 20 to 30 bus. of seed per acre is an average yield. When grown for ploughing in green or for folding, lupins may be sown any time from April to the middle of July. Opinions differ in Suffolk as to whether the best results are obtained with succeeding crops when the lupins are harvested for seed, folded, or ploughed in green. Some advocate harvesting whilst others prefer ploughing in green. Provided a good market exists for the seed there can be very little doubt that the financial return will usually be greater where the crop is harvested. It frequently happens, however, that lupins cannot be conveniently sown early enough for the seed to ripen. They may quite well be sown after cleaning the land and making a spring fallow, or on land which during the winter and spring carried a crop of rye or vetches which has been folded off or cut green.

There is a certain amount of risk to the sheep in folding lupins, but this risk is not serious if care be taken, and Suffolk flockmasters fold all classes of sheep except pregnant ewes upon them with confidence. The chief point to ensure safety seems to be that the sheep shall not be allowed to commence eating the lupins when hungry. It is also necessary for

them to have a run out upon rough grass or some other feed during the daytime so that their diet shall not consist entirely of lupins. Some flockmasters sow a mixture of lupins, vetches, and oats. This makes an excellent fold, and there is very little danger with such a mixture. If the sheep are allowed to overgorge themselves there is danger of paralysis. They are not more liable to blow or become distended upon lupins than upon other succulent green food, and the danger from paralysis is not great if care is taken. Lupins are very bitter and sheep take a short time to get accustomed to the taste, but they soon become very fond of them and will then thrive well, especially if there is a certain amount of seed in the pods.

In his work on the *Scientific Feeding of Animals*, Kelner, however, takes a somewhat grave view of the danger involved in consuming lupins. On the other hand, certain American investigators (Dr. Sollman, Marsh, Clawson, and Hadleigh) rather confirm Suffolk experience, and conclude that poisoning in most cases can be avoided even when the plant is abundant by careful handling of the flocks, especial care being taken to see that hungry sheep are not grazed on fields where there is much lupin. They state that permanganate of potash and tea are both good remedies for lupin poisoning. Suffolk flockmasters often have sheep fall down with paralysis due to lupin poisoning and afterwards recover.

Continental writers speak of making lupins into hay. It is evident, however, that lupins are rather too succulent for that process to be very successful in this country in an average season. Kelner gives analysis of lupin silage, and it seems that they are much more suited for silage than for hay under British conditions. Rarely if ever have lupins been made into either hay or silage in Suffolk.

In pre-war time there was sometimes a difficulty in disposing of the lupin grain, owing to its bitterness and somewhat poisonous qualities.

In Suffolk it has been found that lupin grain may be safely fed to sheep at a rate not exceeding ½ bus. daily per 100 sheep, but the feeding must commence gradually. It is not, however, suited for feeding to pregnant ewes. If too much is fed the sheep become paralysed.

In Holland a method has been discovered whereby it is claimed that the poisonous principle in lupin seeds can be removed by steeping. The grain can then, it is stated, be safely used as food for all classes of stock. If this method proves a practical success it will confer a great boon upon lupin growers, as the grain has by analysis a slightly higher food value than the horse bean.

Lupin grain contains 29 per cent of albuminoids compared with 25 per cent in beans, 6 per cent of fat compared with 1·5 per cent in beans, and the starch equivalent is also rather higher with lupins than with beans. It will thus be seen that if a method could be discovered whereby it could be safely used as cattle food, lupin grain would prove extremely

valuable. A ready sale would then be obtained, and the occupiers of poor sandy land would be encouraged to grow what is without doubt a most valuable crop to them.

The wonderful effect of lupins in improving light sandy land appears to be hardly sufficiently appreciated in this country. At the present time, when there is a fear that considerable areas of this type of land will become derelict, the valuable qualities of lupins in benefiting the succeeding crops cannot be too widely known.

WEEDS OF ARABLE AND GRASS LAND

By Professor A. N. M'ALPINE, B.Sc.(Lond.), Assoc.R.C.S.

Part I—General

Native Plants as Sources of Weeds.

Two kinds of plants populate the arable and grass land of a farm—crops and weeds. The crop plants are introduced and cultivated for economic reasons; the weeds are usually native or natural plants which migrate from their natural breeding grounds and introduce themselves. Certain of these natives are faithful followers of man and of his plough: these are the predominant weeds of cornfield and arable land. Certain other natives haunt the meadows and the pastures: these are the common weeds of grass land. Still other weeds find themselves at home alike on arable and on grass land; in such cases no sharp line of demarcation can be drawn between arable land and grass land weeds. The useful point to notice is that change from arable to grass land will eliminate most arable land weeds, e.g. Couch Grass; whereas change from grass land to arable land will eliminate others, viz. those weeds strictly native to grass land. This change from arable to grass land and vice versa is one of the most valuable methods of exterminating weeds which are naturals or natives specially adapted to the land, and the land to them. Ousting these natives otherwise is a matter of extreme difficulty. Colonists are always ready to come in when their predecessors have been ousted—an ingress specially easy when the land is lying bare and undisturbed.

The main sources from which the land is colonized by weeds will then be got if we enumerate one by one the various natural haunts or habitats of native weed plants. These habitats classified roughly are: (1) cornfields and arable land; (2) grass land; (3) sea coast; (4) woodlands and shady places; (5) roadsides, hedges, field borders, &c.; (6) dry sunny

hillsides; (7) wet land and its borders, ditches, &c.; (8) waste land; (9) marshes and bogs; (10) heaths and moors; (11) rocks and walls; (12) parasites that live not on the land itself, but prey directly upon the crop and ruthlessly destroy it. From these twelve breeding grounds most weeds are derived; others, of course, are introduced from abroad with foreign seeds, some with ballast, and other imports (see "Reproduction and Seed Dispersal", p. 163).

Weeds as Soil Indicators.

Not only do weeds show partiality in their association with arable land and with grass land, but they flourish best in and love soil of a special type. Damp soil, for example, is the favourite breeding ground for some; take away the dampness by draining and these plants dwindle and die out. Some natives, again, thrive and find themselves at home on poor land; remove the poverty by manuring and such plants will for the most part disappear. Other weeds favour land good and rich; wherever these plants are found luxuriant and abundant the soil on which they grow may be regarded as rich. Plants that flourish on dunghills, e.g. White Goosefoot, belong to this group. The group name applicable to these lovers of rich land is *Nitrophile*. Other weeds predominate on calcareous soils; such are called *Calciphiles*. Certain other weeds show decided antipathy to calcareous land, &c.; these shun the lime and those conditions in the soil that arise from the presence of lime; apply lime dressings and such weeds die out and disappear: the group name is *Calcifuge*.

Common weeds that show these special likes and dislikes may now be tabulated.

1. On damp soil: Lady's Smock (No. 31),[1] Field Horsetail (No. 32), Rushes (No. 42), Cowslip (No. 53), Silver-weed (No. 58).
2. Poor soil: Spurry (No. 4), Ox-eye Daisy (No. 11), Ragwort (No. 14), Yorkshire Fog (No. 41), Sheep's Sorrel (No. 51).
3. Good or rich soil (*Nitrophiles*): Common Chickweed (No. 3), Goosefoot (No. 6), Groundsel (No. 10), Dandelion (No. 25), Buttercups (No. 54), Cleavers (No. 59), Stinging Nettle (No. 64).
4. Soil not calcareous (*Calcifuge*): Spurry (No. 4), Corn Marigold (No. 8), Bracken (No. 33), Common Sorrel (No. 52), Sheep's Sorrel (No. 51), Ling Heather.
5. Sandy soil (arenaceous weeds): Spurry (No. 4), Corn Marigold (No. 8), Cornflower (No. 15), Small Bindweed (No. 26), Sheep's Sorrel (No. 51).

Definition of a Weed.

The purpose served by the definition of a weed is very practical; the object is to prevent mistakes into which we might readily fall. The

[1] For reference numbers see p. 169.

weed of arable land presents no difficulty—it is the name assigned to any plant not sown or grown designedly for profit. Difficulty arises when we come to the weed of grass land. One man may seek more profit, another may be quite contented with less, so that what the one would call a grass land weed, the other would call a useful natural plant. Take the difficult case of Common Bent Grass or Agrostis. Some would call this a weed, assuming rightly that more profit would accrue if a better grass were in its place. Another would retort that, anyhow, Agrostis is a useful plant and feeds the beasts; this is quite true, for weeds have uses. The weed question is not one of utility, but of profit, always of profit. Now there is a complete list, not extensive, of the best and most profitable plants for grass production. If the Bent Grass is not in this list then it is a weed; though natural and useful it is one of the plants you would not designedly sow for profit; if you would sow it, then to you it is not a weed. It is sound policy to regard as a weed any plant that you would not sow if you had your choice—the same for arable and for grass land. This definition, however, does not carry us far enough, for the self-same plant may in one set of circumstances be one of the most profitable, in other circumstances one of the most unprofitable—an out and out weed. Take the case of Hard Fescue upon a dry hillside: there it is one of the most valuable grasses, but down in the rich valley, though still useful, it must be kept at a minimum, when maximum profit is the object. Take again Rough-stalked Meadow Grass, a most useful plant, often sown, and rightly so. Nevertheless, Timothy growers will tell you that, in certain Timothy meadows, this meadow grass becomes one of the most troublesome weeds known to them. To a dogmatic person, a weed is a weed and that is the end of it; to another, less dogmatic, circumstances very much alter the case. The important circumstance is maximum profit—not utility, for the idea of utility is too vague and slippery when applied to practice.

Competition between Weed and Crop in the Soil.

Both take up room and want the same water, and exactly the same mineral salts from the soil though in different proportions, depending on the special nature of the plants concerned.

The important point to notice is brought out by considering the effect produced by the presence of a few mustard weeds (Runch or Charlock) in a corn crop. Experiment proves that the injurious effect is out of all proportion to the small number of weeds present. One probable explanation of this is that any scarcity of water or other necessary material in the soil is intensified, because the oats can get only what is left over when the mustard weeds have fully satisfied their wants. Profit from grain raising is much increased when the crop is kept free from weeds.

Competition between Weed and Crop in Air and Light.

Here again both plants take up room, and both want a full light supply to enable the food manufacturing processes to go on in a satisfactory manner. The important point here may be illustrated by considering the case where rapidly growing weeds of tall stature are intermingled with slow-growing crop plants of low stature, e.g. with a root crop—turnip, swede, mangel, or carrot. Here the light supply of the root crop has been partially cut off by the tall weeds at the very period of growth when light supply is of most importance. The yield, of course, is considerably diminished—just because of the diminished light supply. One easily perceives that weed eradication is a matter of moment when maximum yield is the object in view.

The Shade Crop and its Use.

The principle of controlling light supply may at times be turned against the weeds by taking a rapid-growing crop which produces dense shade beneath, e.g. a vetch crop. The weeds near the ground beneath the vetches are inadequately supplied with light, and tend to die out from consequent starvation. Though the soil supplies for the undergrowth are satisfactory enough, nevertheless the manufacturing processes within the plant are checked, for without light supply no food can be elaborated by any normal green plant.

Habits of Growth above Ground.

When one considers how varied are the modes of growth of weeds, how skilful they are in elbowing out the crop plants, and robbing them of their due light supply and other requirements, one becomes alive to the importance of getting rid of weeds. Further, when seed production is the object of the grower, weed and crop grow up together, are harvested and thrashed together, with the result that the useful seeds are often contaminated with weed seeds difficult to eliminate even though special cleaning machinery is used. Thus we find grain contaminated with Corn Cockle (No. 2), Bindweeds (Nos. 26 and 48), and many other seeds; grasses and clovers contaminated with Yorkshire Fog (No. 41), Buttercups (Nos. 54 and 55), and a host of others. Crop yield and crop value, under these circumstances, must become very much reduced.

We now tabulate eight important habits of growth above ground, pointing out the most distinctive features.

1. Erect: when the stem is elongated, at right angles to the ground, e.g. Groundsel (No. 10), Shepherd's Purse (No. 30).

2. Prostrate or trailing: when the stem is elongated in the horizontal direction along the ground. Here the stems are weak and deficient in skeleton, e.g. Chickweed (No. 3), Field Madder (No. 60).

3. Surface creeping or running: as before, but rooting at the nodes for the special purpose of vegetative propagation, e.g. Creeping Buttercup (No. 55), Silver-weed (No. 58).

4. Twining: when the slender stem describes a spiral line round a support (say a cornstalk), and as it goes round produces leaves well exposed to light, e.g. Small Bindweed (No. 26), Black Bindweed (No. 48).

5. Climbing by hooks: when the slender stem gets its leaves up to the light by hooking on to neighbouring plants used as a support, e.g. Cleavers (No. 59).

6. Climbing by tendrils: here again the stem is weak and gains the light supply for its leaves by using tendrils. The tendril itself is an elongated thread-like outgrowth which describes a spiral line round a support, e.g. Hairy Tare and Climbing Vetch.

7. Tufted: when many stems instead of one are produced close together at or near the surface of the ground.

8. Rosette: when the numerous leaves borne on one stem become closely packed together at the ground by excessive shortening of the stem internodes, e.g. Daisy (No. 13), Dandelion (No. 25). (See Part II, p. 169.)

Annual and Biennial Weeds.

The term *annual* is applied to a plant when so rapid of growth, and so highly gifted with reproductive power, that in a single season of life it produces its roots, its shoots, its flowers, its fruits, its seeds, and then dies completely, leaving nothing behind but numerous seeds to produce a new brood of plants next spring. Its one aim is seed production —all its substance is devoted to this. Such a plant will rapidly overrun a large area of ground. There are plants, e.g. Groundsel, even more rapid and less lasting than the annuals; these in the course of a single season produce seeds and die, the seeds in turn produce a new brood, the new brood produces other seeds, and so on; these seeds germinate, and thus brood upon brood is produced in a single season. Plants that can produce several broods in the course of one season are called *ephemerals.*

The term *biennial* is applied when two seasons are required to complete the life of a single generation of the plant, and under normal conditions the first season is entirely devoted to the production of root and shoot. Surplus food is manufactured and stored up in safety to a large extent within the enlarged underground root. The shoot which manufactures all the food used by the plant assumes the form of a green rosette at the ground crowning the storing root parts. The plant rests during winter. During the second year of life, the bud in the centre of the leaf rosette grows up and forms a reproductive apparatus with flowers, and ultimately fruits and seeds. When these seeds are scattered the plant dies from exhaustion. No food and no buds are left behind to continue the growth. Though the parent dies, the numerous seeds left behind produce a new brood of biennial plants (see " Perennial Weeds ", p. 164).

Reproduction and Seed Dispersal.

All weeds may be, but annuals and biennials must be introduced into the land in the form of "seeds". If the seeds could be kept out no annual or biennial weeds could be present, though perennials might still appear. Now annuals and biennials are, of all plants, the most prolific seed makers, and another point that favours their abundance is the *gradual* production of seed, the period of seed production often extending over months, under varying circumstances more or less favourable for dispersal and successful occupation of new territory.

Seven important natural adaptations for securing dispersal of seeds are:

1. The seeds very small and light, readily carried to a distance by the wind, e.g. Shepherd's Purse, Poppy, &c.
2. The seeds produced within a fruit case, which bursts explosively and shoots out the seeds to a distance, e.g. Geraniums.
3. The individual seeds flat and provided with a thin wing all round for wind dispersal, e.g. Yellow Rattle.
4. The individual seeds of low weight enclosed within light chaff very easily transported by wind, e.g. Yorkshire Fog.
5. The individual seeds enclosed within a light fruit case (pericarp), which is provided with an apical tuft of long hairs or feathers; the whole acting as a flying machine, with encased seed as passenger, e.g. Thistles and Dandelions.
6. The individual seeds enclosed within a fruit case (pericarp) provided with hooks on its surface to catch on the coats of sheep and other passing animals, e.g. Cleavers.
7. Certain seeds are hard and pass undigested through the alimentary tract of animals; these come out uninjured in the dung, under conditions favourable for successful germination and growth.

The above examples show that wind and animals are the chief agents concerned in the spread and introduction of weed seeds to new land; also that precautions must be taken if weed seeds are to be kept from spreading.

In addition to these natural adaptations for seed dispersal, there are four other agencies at work. These are worth noting, specially because often overlooked.

1. Seeds with their impurities are imported from foreign lands. Thus troublesome foreign weeds are introduced.
2. Manure, litter, and forage may contain many seeds which readily get into the land unless special precautions are taken.
3. Travelling mills often bring in weed seeds.
4. The sweepings of hay lofts are loaded with weeds, usually Yorkshire Fog and Soft Brome Grass. The danger of contaminating the land from this source should be carefully guarded against. Such sweepings should neither be incorporated in the manure heap nor be sown on the land.

Perennial Weeds—their Renewal: the Rhizome for securing Longevity.

Annuals and biennials are reproduced from seeds as starting-points. Perennials are also reproduced from seeds, but they have another starting-point which is not a seed. The addition of this second string to the bow of a perennial weed is the source of its power of renewal and tenacity of life. Renewal is not reproduction from a seed—the seed makes a new generation.

To understand how woody perennials, our common shrubs and trees, our whins and hawthorns and oaks, renew their growth is easy enough. This renewal depends upon: (1) the presence of living stems with buds upon them for making new branches; (2) the presence of surplus food stored in the stems; (3) the presence of living roots in the ground. A fourth point may here be noted, namely the tendency of the stem to form roots of its own when in contact with moist earth—easily noticed when a cutting is struck. Now the perennial weed which is neither shrub nor tree is in this position; it forms special underground living stems stored with surplus food, bearing buds and leaves, and forming roots. This underground part is called the *rhizome*; when the portions above ground die away, the rhizome with its buds, its food store, and its roots still persists and remains alive. The possession of this rhizome confers upon the perennial weed the special power of lasting and renewing its growth from year to year. Destroy the rhizome and the life of the whole plant is at an end; leave a piece of the rhizome in the ground and the growth is still capable of being renewed and extended.

Habit of Growth Underground: Three Forms of Rhizome.

On p. 161 the habits of growth of the stems above ground were dealt with. Here we consider the habit of growth of the rhizome underground.

1. The erect rhizome, e.g. Dandelion (No. 25), Dock (No. 50). In such cases as these the vertical rhizome is stout, with abundance of stored food, and forms a crown shoot with green leaves at the apex.

2. The corm rhizome, e.g. Bulbous Buttercup (No. 57), Earth-nut, Colchicum. In these cases the rhizome is vertical, short, and extra stout, with fibrous roots but no tap-root.

3. The creeping rhizome, e.g. Couch Grass (No. 38). This is the most common form. The rhizome grows in the horizontal direction, and bears buds, leaves, and fibrous roots.

There are other rhizome forms, e.g. bulbous rhizome of onion and tuberous rhizome of potato. These are not considered in this article on weeds.

All plants with rhizomes are called *rhizomatous* plants. From a practical point of view, the weeds with creeping rhizomes are of most importance. The useful name applied to these is *underground creepers*, to distinguish from *surface creepers* with the stem horizontal above the surface of the ground.

Common examples of these underground creepers are:

(*a*) Those with deep rhizomes beyond reach of the ordinary plough—Coltsfoot (No. 12), Creeping Field Thistle (No. 17), Field Horsetail (No. 32), Bracken (No. 33).

(*b*) Those with fairly shallow rhizomes—Couch Grass (No. 38), Rushes (No. 42), Stinging Nettle (No. 64), Corn Mint, &c.

Mutual Dependence of Rhizome and Green Parts.

The practical importance of recognizing interdependence of rhizome and green parts above ground lies in this, that an otherwise inaccessible rhizome may be readily got at and exploited through the more accessible green parts. The underlying reason is that the rhizome has no source of food supply other than the green parts—and that the green parts themselves have no starting-point or origin other than the rhizome itself. Take away the green parts before they have time to return a recharge of food supplies and you ultimately get a starved and dead rhizome. Take away the rhizome completely and the green parts cannot be renewed. It is easy to make mistakes when dealing with the rhizome in practice. One tempting mistake is to remove the leaves at a convenient time which is too late, since the leaves have already returned food supplies to the underground parts sufficient to keep the plant going. Another tempting mistake is to remove part of the rhizome, and then imagine that the whole has been removed or that it does not matter much though a part of the rhizome is left behind. The bit almost inevitably left behind is the true focus of interest; how is it to be looked after?

The best plan when getting rid of rhizomes is to remove as much of them as you can and burn them. Focus your attention on the parts left. Make arrangements for clearing out the shoots which will assuredly be produced from these residual parts. If this is efficiently done, the rhizome and all its parts are starved to death and are done with. If this cleaning-up work is neglected, new rhizomes and plants will develop and your work has been in vain.

Natural Vegetative Propagation.

Two methods: (1) surface propagation; (2) underground propagation.

When the process of vegetative propagation is going on, no seeds, no germinations, no embryo plants, no seedlings are involved; if they were,

reproduction would be the appropriate name, not propagation. It is the actual body of the plant, not the flowers, not the seed-making machinery, not the seeds, that is involved in the propagative process. The object of this process is to transform a plant with one body into many quite distinct plants, each with its own special body. For this propagation the plan usually followed by the plant is to disjoin and sever certain parts. Take Creeping Buttercup (No. 55) as an example of vegetative propagation above ground. In this, the habit of growth is characteristic: a number of creeping stems grow out. These—runners they are called—become disjoined and severed into distinct pieces by the dying away of intermediate portions. Each severed piece becomes a plant with a body of its own; many plants have been made from one. This is vegetative propagation.

Take Pearl Grass (No. 37) as a case of underground propagation. Here the body is a tuft of stems rising from below the ground. The underground part of each stem forms a chain of swellings, chain alongside of chain, one chain from each stem of the tuft. The swollen links of each chain become disarticulated, and the severed link can become a new plant with a body of its own. This again is vegetative propagation. The farmer calls each severed portion of the stem a pearl, sometimes a knot, sometimes a bulb, and so forth.

Induced Propagation.

Power of propagation is a prerogative of perennial plants. Under certain conditions, however, any perennial may be induced to propagate; many troublesome weeds are adepts at this business. Take an underground creeper such as Couch (No. 38). The farmer with his plough cuts the underground creeping stem into pieces; each piece, if left undisturbed, forms its own body; its own creeping stem, &c. This is propagation induced by cutting.

Take a Dandelion (No. 25) and cut off its crown with a spud. A regular crop of Dandelions spring up from the stump of tap-root left behind in the ground. Here the root does the propagation business, so this is a case of induced propagation from the tap-root, not from the rhizome. Spud off the crown of a Dock, and we get a case similar to that of the Dandelion—induced propagation from the tap-root.

We now see that all our common weeds (except Horsetail and Bracken, which use spores for the purpose of reproduction) are reproduced from seeds, and that all perennial weeds can not only reproduce but propagate, usually from the stem (Couch), but sometimes from the root (Dandelion and Dock). We further see that mutilating and cutting perennial weeds, if unskilfully done, may induce propagation for self-preservation of the individual.

Three Weak Points in the Life of Weeds.

All weeds pass through the seedling stage of growth (or the spore-derived equivalent in such cases as Horsetail and Bracken). This seedling is at the change of life—the change from dependence on parental food supplies to reliance on food products resulting solely from its own activity. At this stage minimum food is in reserve. This is the first point of weakness to be noticed—the seedling stage of weakness. Catch the plant at the seedling stage and destruction is most easy. A seedling uprooted has no wherewithal of food to enable it to grow back into the soil. A seedling put out of reach of light by a covering of earth must die of sheer starvation.

This weakness at the seedling stage is taken advantage of in spring cultivation—the seeds are induced to germinate and the resulting seedlings uprooted or buried and so destroyed completely. But seedlings do not come up at one time to suit the convenience of the farmer. Many successive uprootals and burials would be necessary to catch the seedling stage of weakness. Just here comes in the value of the root crop: this allows successive seedlings to be dispatched by the hoe as and whenever they come up. In a grain crop hand pulling and other devices have to be resorted to, and besides, the weed plants have advanced beyond the seedling stage, which renders destruction more difficult.

The second point of weakness in the life of weeds is on the stubble in autumn. Under the grain crop the perennial weeds have been drawn up, elongated, more or less blanched, and weakened, and any rhizomes present are at their nearest to the surface, under conditions most favourable for removal. Autumn cultivation selects this moment to attack the plants partially starved under the grain crop; the winter frost finishes the work.

There is a third weak moment, of great importance in practice because it affects these most stubborn weeds—the underground creepers. After the rhizomes of these have have been partially removed, the weak moment of the residual parts occurs when the green parts emerge. Accordingly arrangements should be made to enable these young shoots to be caught in a root crop or otherwise before they have time to become thoroughly established in the land. Even two root crops may be necessary to catch stubborn weeds at their weakest.

Prevention of Seed Formation: Three Points.

If the seedling is destroyed, then of course there is no question of seed production. When the weed has passed the seedling stage, more especially if a quick-growing annual, the plant should be destroyed early, for sometimes seed making begins after a few weeks' growth. Early attack is in all cases the important matter. Take Coltsfoot (No. 12),

which flowers and seeds quite early in spring, even before the green leaves appear; if the earliness is forgotten and the weed allowed to scatter its seed, whole areas of land will be contaminated by a new brood of Coltsfoot weeds. Again, take Horsetail (No. 32). This weed reproduces not by seeds but by spores which are formed quite early in the year. To prevent spread by spores, destruction should take place before these spores are scattered over the land. In practice this is usually forgotten, and Horsetail is allowed to scatter its spores and reproduce without let or hindrance.

Another point often neglected is exemplified by Thistles (No. 16). One frequently sees cut thistle stems lying on the ground bearing seed in abundance; one sees these seeds flying away with the wind to form new colonies of Thistles on other parts of the farm. Here the cutting has been too late: the process called "after ripening" has taken place, and the seeds have matured on the cut stems. This again emphasizes the vital importance of early destruction or cutting if the weeds are to be prevented from forming and maturing seed after cutting has taken place.

If the weeds formed seeds only on the farmed land then attention could be confined solely to farmed land. But a moment's consideration of the various sources of weeds (see p. 158) shows the necessity of attending to the plants growing in the neighbourhood, more especially to those in the ditches, field borders, and hedges: to keep the land clean these sources of weed contamination must be carefully looked after.

Seven Methods of Extermination for Weeds in Arable Land.

Here are the main methods employed in practice.

1. Seed burial by the plough.
2. Burial of the plants.
3. Spring cultivation.
4. Hand-pulling.
5. Growth of a root crop.
6. Growth of a shade crop.
7. Change from arable to grassland.

General Method for Extermination of Weeds in Grass Land.

Here there is one main method, namely: plough up, carefully clean and take one root crop at least, then reseed with a suitable seeds mixture.

Five Special Methods for Dealing with Weeds.

1. Drain to get rid of the weeds of wet land.
2. Lime to rid the land of the calcifuge weeds.
3. Enrich to get rid of the weeds natural to poor land.
4. Change from meadow to pasture and vice versa to alter the weed herbage.
5. Vary the animals which graze the pasture; see Ragweed (No. 14).

Differential Sprays for Weeds.

There are poisonous solutions which are used chiefly for the destruction of mustard weeds (Charlock, No. 28, and Wild Radish, No. 29) in grain crops: the grain crop rapidly recovers from any injury due to the spray.

1. Sulphate of copper, 5 per cent solution: 40 gall. per acre.
2. Iron sulphate, 7 per cent solution: 40 gall. per acre.

Part II—Descriptive

Classification.—The weeds dealt with are arranged botanically according to their natural orders; for convenience these are in alphabetical order. Three kinds of weeds are distinguished: (1) those of arable land; (2) those common to arable and grass land; and (3) those peculiar to grass land.

To prevent ambiguity the nomenclature adopted is that used in Hooker and Bentham's *British Flora.*

Common Names.—The weeds described are numbered consecutively to facilitate the use of common names. These common names and numbers are now given.

Common Names

Acrid Buttercup, 56.
All-heal, 44.
Autumnal Hawkbit, 23.

Bearbind, 26.
Bedstraw, 61.
Bent, 40.
Bent, Black, 40.
Bent Grass, 40.
Benweed, 14.
Bethbind, 26.
Bindweed, 26, 48.
Bitter Cress, 31.
Black Bent, 40.
Black Bindweed, 48.
Black Knapweed, 19.
Blaw Weary, 44.
Blue-bottle, 15.
Bracken, 33.
Brake, 33.
Brome Grass, 39.
Bulbous Buttercup, 57.
Bulbous Oatgrass, 37.
Buttercup, 54, 55, 56, 57.

Campion, 1.
Carrot, Wild, 63.
Cat's Ear, 24.
Charlock, 28.
Cheese Rennet, 59.
Chickenweed, 3, 5.
Chickweed, 3, 5.
Cleavers, 59.
Climbing Buckwheat, 48.
Clover Dodder, 27.
Cockle, 2.
Coltsfoot, 12.
Common Bent, 40.
Common Chickweed, 3.
Common Nettle, 64.
Common Rush, 42.
Common Sorrel, 52.
Convolvulus, 26.
Corn Buttercup, 54.
Corn Cockle, 2.
Corn Feverfew, 9.
Cornflower, 15.
Corn Marigold, 8.
Corn Mustard, 28.
Corn Poppy, 46.
Corn Rose, 46.
Corn Sowthistle, 20.
Couch, 38.
Couch Grass, 38.

Cowslip, 53.
Crane's Bill, 34, 35.
Craw-taes, 56.
Creeping Buttercup, 55.
Creeping Rest-harrow, 45.
Creeping Thistle, 17.
Crowfoot, 55, 56.
Cuckoo-flower, 31.
Curled Dock, 50.
Cut-leaved Geranium, 35.

Daisy, 13.
Dandelion, 25.
Devil's Guts, 27.
Dock, 50.
Docken, 50.
Dodder, 27.
Dog Daisy, 11.
Dove's Foot Geranium, 34.
Dwarf Thistle, 18.

Equisetum, 32.
Erect Buttercup, 56.

False Oat, 37.
Fat Hen, 6.
Fern, 33.
Field Bindweed, 26.
Field Horsetail, 32.
Field Madder, 60.
Field Thistle, 17.
Field Woodrush, 43.
Foal's Foot, 12.

Geranium, 34, 35.
Goosecorn, 6.
Goosefoot, 6.
Goosegrass, 6.
Gowan, 11.
Great Nettle, 64.
Grip Grass, 59.
Groundsel, 10.
Ground Thistle, 18.
Gule, 10.

Hardheads, 19.
Haver, 36.
Havers, 36.
Hawkbit, 22, 23.
Horse Daisy, 9.
Horse Gowan, 11.
Horse Knot, 19.
Horsetail, 32.

Jointed Charlock, 29.

Knapweed, 19.
Knobweed, 19.
Knotgrass, 37.

Lady's Bedstraw, 61.
Lady's Smock, 31.
Lamb's Quarters, 6.
Lesser Bindweed, 26.
Long-headed Poppy, 47.
Long-rooted Cat's Ear, 24.
Lychnis, 1.

Madder, 60.
Marigold, 8.
Mayweed, 9.
Mildweed, 6.
Mouse-ear Chickweed, 5.
Mustard, Wild, 28, 29.

Nettle, 64.
Nipplewort, 21.

Oat, False, 37.
Oat, Wild, 36.
Onion Couch, 37.
Ononis, 45.
Orache, 7.
Ox-eye Daisy, 11.

Paigle, 53.
Pearl Grass, 37.
Pee-a-bed, 24.
Perennial Sowthistle, 20.
Persicaria, 49.
Polygonum, 48, 49.
Poppy, 46, 47.
Pteris, 33.
Puddock Pipes, 32.

Quickens, 38.
Quitch, 38.

Radish, Wild, 29.
Ragweed, 14.
Ragwort, 14.
Rashes, 42.
Rattle, Yellow, 62.
Redshank, 49.
Rennet, 61.
Rest-harrow, 45.
Robin-run-the-hedge, 59.
Rough Hawkbit, 22.
Runch, 29.
Rushes, 42.

Scarlet Poppy, 46.
Scentless Mayweed, 9.
Scotch Thistle, 16.
Scutch, 38.
Self-heal, 44.
Sheep's Sorrel, 51.
Shepherd's Purse, 30.
Sherardia, 60.
Shetland Oat, 36.
Silver Weed, 58.

Skelloch, 28.
Small Bindweed, 26.
Soft Brome, 39.
Soft Grass, 39.
Sorrel, Common, 52.
Sorrel, Sheep's, 51.
Sour Dock, 52.
Sourocks, 52.
Sowthistle, 20.
Spear Thistle, 16.
Spreading Orache, 7.
Spurry, 4.
Stemless Thistle, 18.
Sticky Willy, 59.
Stinging Nettle, 64.
Strangle Weed, 27.

Thistle, 16, 17, 18.
Tussilage, 12.
Twitch, 38.

Upright Buttercup, 56.

White Campion, 1.
White Charlock, 29.
White Goosefoot, 6.
White Ox-eye Daisy, 11.
Wild Carrot, 63.
Wild Convolvulus, 26.
Wild Liquorice, 45.
Wild Mustard, 28.
Wild Oat, 36.
Wild Radish, 29.
Willow Weed, 49.
Woodrush, 43.

Yarr or Yawr, 4.
Yellow Bedstraw, 61.
Yellow Ox-eye, 8.
Yellow Rattle, 62.
Yorkshire Fog, 41.

Eleven descriptive details for each weed are arranged in the following order:

1. Colour of flower: indicated by the first letter after the reference number of the weed.

B., blue.	R., red.
Br., brown.	Ro., rose.
Cr., crimson.	Sc., scarlet.
Gr., green.	Vi., violet.
Li., lilac.	W., white.
Pk., pink.	Y., yellow.
Pu., purple.	Pl., pale.

2. *Duration.*—This is indicated after the number and colour by letters:
   A., annual.
   B., biennial.
   P., perennial.
3. One of the common names. Others are given in the list of common names, p. 169.
4. Botanical name as given in Bentham and Hooker's *British Flora.*
5. Height of the plant when in flower; if the flowering stems are prostrate, the horizontal length of the stem is stated.
6. The character of the soil.
7. Habitat.
8. Habit of growth.
9. Reproduction and dispersal.
10. Renewal, when the weed is perennial.
11. Eradication.

When appropriate, additional points noticed are: method of propagation, poisonous or special properties, and description of the seed.

NATURAL ORDER, CARYOPHYLLACEÆ.

Stems with swollen nodes. Leaves opposite and entire; stipules in the case of Spurry (No. 4).

ARABLE LAND

1. W. P.[1] White Campion (*Lychnis vespertina*).

Height.—1 to 2 ft.

Flowering.—May to August. On all soils; light and calcareous preferred

[1] Throughout, the number gives the reference, the first letter indicates the colour of flower, and the second letter the duration of the plant.

Habitat.—Very common in cornfields, arable land, temporary leys of grass and clover.

Habit of Growth.—The whole plant is covered with soft spreading hairs, which are slightly viscid on the upper parts. A few short barren shoots and leafy stems grow erect out of the ground. The lower leaves 3 to 6 in. long are ovate lanceolate and attenuated into long foot-stalks, whereas the upper leaves are sessile. The flowers are few, large, and pedunculate. The first flower terminates the stem; the peduncle of this forms a pair of branches with a pair of leaves, each branch with its own terminal flower—thus the terminal dichasium is built up.

[1]Fig. 1.—White Campion (*Lychnis vespertina*)

1, Petal; 2, plant, upper part; 3, five-styled gynæcium.

Separation of the Sexes.—On one plant the flowers are male with stamens only, on another female only, with a five-styled gynæcium. This plant is accordingly diœcious.

Reproduction.—When the female plant is bearing, the hard tough conical fruit is found filling the calyx, sometimes bursting it. For seed dispersal, ten teeth at the top of the capsule open out straight and erect, and the numerous small seeds come pouring forth from the shaken capsule through the open mouth. Thus the Campion strews over the ground numerous seeds for producing a new brood.

Renewal.—Underground there is a thick and almost woody stem (rhizome) from which new barren shoots and stems are produced.

Description of Seed.—This often occurs as an impurity in clover seed. It is kidney-shaped, 2 by 1½ mm., and lies on its flattened side; the surface is pale greyish green with numerous small peg-like projections arranged in concentric lines. Unlike Poppy, Campion seeds leave no oily mark when crushed on a sheet of white paper.

Eradication.—Prevent seeding by hand pulling or otherwise.

2. Pu. A. **Corn Cockle** (*Lychnis Githago*).

Height.—1 to 4 ft.

Flowering.—July to August. On all soils.

Habitat.—A common cornfield weed, belonging more especially to the wheat crop.

Habit of Growth.—This plant is covered with adpressed white hairs. From a tap-root a solitary erect and slender stem grows up, sometimes bear-

[1] Figs. 1, 3, 6–12, 14–17, 19–30, 32 are reproduced by permission of the publishers of Fitch and Smith's *Illustrations of the British Flora* (Messrs. L. Reeve & Co., Ltd.).

ing a few ascending branches. The leaves are opposite, sessile, narrow, and lanceolate. The flowers are large and conspicuous, $1\frac{1}{4}$ in. or more across, terminating slender peduncles. They stand solitary in the axils of the leaves. The calyx has five pointed woolly teeth projecting far beyond the petals, and the styles are five in number.

Reproduction.—At maturity the ovoid capsule fruit containing twenty or thirty seeds is found within the swollen calyx. To disperse the seeds, five teeth open out at the summit, and through the open summit the seeds are discharged separately to produce a new brood of Cockle plants. The parent plant dies after seed scattering—it is an annual.

The Seed and its Properties.—This seed sometimes occurs as an impurity in wheat and contains a poisonous glucoside. Accordingly no grain containing Cockle should be given to poultry or farm animals, no food-stuff containing it should be allowed on the farm.

The seed is somewhat kidney-shaped, 3 or 4 mm. long by 2 or 3 mm. broad, with one end narrowed into a beak. The skin is coal black and rough, with numerous peg-like projections arranged in concentric rows: the contents are chalky white, and when rubbed up in water produce a soapy foam.

Eradication.—

1. Do not sow seed containing this impurity.
2. Use all means to prevent seeding in the cornfield.

3. W. A. Common Chickweed (*Stellaria media*).

Height.—3 to 18 in.

Flowering.— February to October. On all soils; rich preferred (a nitrophile).

Habitat.—Very common on cultivated and waste land.

Habit of Growth.— The stem bears a narrow strip of hairs; the rest of the plant is glabrous. This strip of hairs is not continuous along the stem, but changes side from right to left and from left to right, at the end of each successive internode. From the tap-root a loose tuft of weak leafy stems grows out, spreading away from one another with their

Fig. 2.—Common Chickweed (*Stellaria media*)
1, Cloven petal; 2, three-styled gynæcium; 3, six-toothed fruit.

bases on the ground; these stems branch freely. All the leaves are arranged in opposite pairs; on the lower parts the petiole is as long as the ovate blade, whereas on the upper parts the leaves are sessile.

The flowers are small and numerous, with long peduncles. They are not produced in groups, but singly, one from the axil of a pair of leaves. Cloven petals and three styles are distinctive features.

Reproduction.—When bearing, an ovoid capsule is found within the calyx. To scatter the numerous small seeds six teeth or valves are formed at the apex of the capsule, and from the opening the seeds are shaken out separately to the ground, where they produce a new generation. The exhausted parent then dies—it is an annual.

Eradication.—Thorough cultivation, deep ploughing, and the use of the skim coulter reduce this weed.

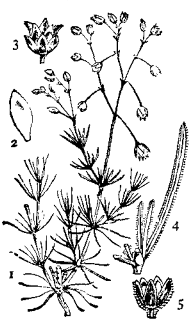


Fig. 3.—Spurry (*Spergula arvensis*)

1, Plant in flower and fruit; 2, petal; 3, fruiting shoot; 4, leaf with leaves of axillary dwarf shoot; 5, floral shoot.

4. W. A. **Spurry** (*Spergula arvensis*).

Height.—4 to 15 in.

Flowering.—June to August. An indicator of sandy and very light soil, deficient in lime salts (calcifuge).

Habitat.—Common in cornfields and arable land. Often very troublesome.

Habit of Growth.—This is a plant with clammy glandular hairs, especially on the upper parts. From the tap-root a loose tuft of slender stems grows up, *not straight*, but bending at the nodes and following a zig-zag course. The leaves are shaped like fine awls about 1 in. long, and arranged in distant pairs. Special dwarf shoots are also formed in axillary pairs; the opposite leaves of these shoots are compacted and spread out round the parent stem; thus the stems of Spurry appear to bear distant whorls of leaves.

The stem terminates in a solitary flower with a long peduncle; from this initial peduncle an opposite pair of pedunculate flowers branches out; from each of these still another pair, and so on. The ultimate result is the formation of a terminal floral region built up of forked branches, with a solitary flower in each fork.

Reproduction.—At maturity the slender peduncle $\frac{1}{2}$ to 1 in. long bends down, bearing at its summit the persistent calyx filled by a somewhat globular slightly projecting capsule fruit. To permit dispersal of the seeds within the capsule, five valves form at the apex and open out. Now the seeds become detached and fall away through the openings. The better to utilize the wind and to scatter more widely, these seeds are

compressed and provided with a narrow wing extending round the whole margin.

Eradication.—

1. Dressings of lime are useful for the reduction of this calcifuge.
2. Destroy the seedlings and prevent seeding by spring cultivation and harrowing.

ARABLE AND GRASS LAND

5. W. A. or B. **Mouse-ear Chickweed** (*Cerastium vulgatum*).

Height.—3 to 15 in.

Flowering.—April to October. On all dry and light soils.

Habitat.—Common in fields, waste land, and grass land.

Habit of Growth.—The whole plant is pale from the clothing of white hairs. From the tap-root a loose tuft of numerous stems more or less prostrate and branched grows out. The leaves are arranged as opposite pairs; the individual leaf is broadly lanceolate and sessile. A leafy cluster of small white flowers is developed at the terminations of the stem and its branches. The cleft petals and the five styles are distinctive features of the very small flower.

Reproduction.—At maturity a curved cylindrical capsule fruit girt round its base by the persistent calyx is found. To disperse the numerous seeds, the capsule opens at its apex by ten teeth and the seeds are rapidly poured out through the open mouth. The seeds are so numerous, and germinate so rapidly, that the young Chickweeds often form dense matted tufts, interfering much with the growth of the crop.

Eradication.—Thorough cultivation, deep ploughing, and the use of the skim coulter may prove effective.

NATURAL ORDER, CHENOPODIACEÆ.

Leaves with no stipules. Flowers small, grouped into dense inflorescences.

ARABLE LAND

6. A. **White Goosefoot** (*Chenopodium album*).

Height.—6 to 24 in.

Flowering.—June to October. On all soils, rich preferred; plant nitrophilous.

Habitat.—Common on dunghills, cultivated, and waste land.

Habit of Growth.—This plant usually appears as if sprinkled with white meal, which is accounted for by the presence of peculiar short hairs most abundant on the lower surfaces of the leaves and on the perianths of the flowers. From the tap-root the tough stem rises erect, and soon begins to form alternate branches which grow out fairly erect from the axils of the stalked leaves. The very small flowers are produced in

profusion. They form small ball-like clusters which sit crowded on the slender terminations of the stem and branches, as well as on special short leafless axillary branches specially produced for flower bearing. These clusters taken together constitute the terminal axillary spikes, each about $\frac{1}{2}$ in. long.

Fig. 4.—White Goosefoot (*Chenopodium album*)
1, Flower; 2, plant in flower and fruit.

Reproduction.—The fruit is formed within the persistent perianth of the flower. The fruit case is short, broad, and membranous, fitting closely upon the single flat glossy seed within. Material in plenty for reproducing quite a large brood of Goosefoot plants is left behind by the dead parents.

Identification.—

1. A mealy plant; leaves alternate with a petiole $\frac{3}{4}$ to 2 in. long, and a blade about the same length.

2. The leaf-blade is of rhomboid outline, with the wedge-shaped basal portion entire; the apical portion usually bears blunt teeth.

9. The upper leaves connected with the floral region are lanceolate and entire.

Eradication.—

1. Surface cultivation in spring: hand pull any plants that escape.
2. Thoroughly hoe the root crop.

7. A. **Spreading Orache** (*Atriplex patula*, var. *angustifolia*).

Height.—6 to 18 in.

Flowering.—July to September. On rich soils (a nitrophile plant).

Habitat.—Chiefly on cultivated land: the weed dominates land rich in nitrogenous compounds.

Habit of Growth.—The plant is dull dark green, more or less covered with short hairs which produce a mealy appearance, most pronounced on the young plants. The stem bears long weak basal branches diverging at a right angle. The leaves on the lower parts are narrow and lanceolate. The flowers are compacted into small clusters arranged loosely

along the much elongated slender terminal parts of the stems involving some of the green leaves. These are the compound terminal spikes.

Reproduction.—The fruit is found on the spikes enclosed between two specially enlarged bracteoles, which take the form of rhomboids 2 or 3 mm. long by 2 mm. broad, very much larger on rich land, 10 by 5 mm. The compressed fruit within the bracteoles consists of a thin membranous case, easily rubbed off, with a single black polished seed within.

Eradication.—

1. Destroy the seedlings by spring cultivation.
2. Hand pull any plants noticed in the corn.
3. Thoroughly hoe the root crop to destroy the young plants.

NATURAL ORDER, COMPOSITÆ—DAISY TYPE.

Juice watery.

ARABLE LAND

8. Y. A. **Yellow Ox-eye** (*Chrysanthemum segetum*).

Height.—12 to 18 in.

Flowering.—June to October. An indicator of sandy and light land, also a calcifuge, i.e. shuns lime.

Habitat.—Frequent in cornfields, potato-fields, turnip-fields, and arable land.

Habit of Growth.—This Ox-eye is glaucous and glabrous. From the tap-root an elongated leafy stem grows up erect, bearing on its sides a few elongated branches also somewhat erect. The lower leaves are obovate and stalked, the upper narrow and clasping the stem, with a few deeply cut teeth at the apex. The flower-heads are large, about 2 in. across, with a yellow ray and a yellow disc; they are borne on hollow peduncles which terminate the stem and its branches.

Reproduction.—In fruit, the light achenes are seated on the almost flat axis of the head within an involucre of green bracts with a broad membranous margin. The achenes are strewn from the head on to the ground around or may be blown by the wind to adjoining fields, there to produce the new generation; then the parent plant dies completely —the plant is annual.

Eradication.—

1. Spring cultivation will destroy many seedlings.
2. Hand pull any plants in the corn and burn them.
3. Take several root crops in succession and thus destroy the young plants.
4. Dressings of lime tend to reduce this calcifuge weed.

9. W. A. **Scentless Mayweed** (*Matricaria inodora*).

Height.—1 to 2 ft.

Flowering.—June to October. On all soils. A calcifuge, i.e. shuns calcareous land.

Habitat.—Common in cornfields, arable and waste land.

Habit of Growth.—This plant is glabrous and dark green. From the tap-root a tuft of fairly erect leafy stems, formed by basal branching, grows up. Each of these stems is again branched on its upper part. At each termination a solitary pedunculate flower-head with a white ray and a yellow disc, the whole about 1 in. across, is developed. The leaf is sessile, with an elongated midrib branched and rebranched, and clothed with short green hair-like segments; when bruised this leaf emits little or no odour—hence the name.

Reproduction.—The achene fruits are found seated on the somewhat conical axis of the head, surrounded by the flat involucre of blunt pointed scales edged with brown. These achenes are shed around to produce a new brood; then the parent dies completely—the plant is annual.

Eradication.—

1. Hoe out young plants.
2. Prevent spread by seed as far as possible.

10\. Y. A. **Groundsel** (*Senecio vulgaris*).

Height.—3 to 12 in.

Flowering.—April to December. On all soils; light and rich preferred.

Habitat.—Very common in cultivated and waste ground, &c.

Habit of Growth.—This is a succulent glabrous, sometimes cottony, plant without ray florets in the flower heads. From the shallow root the erect branched stem grows up. The leaves have a long midrib in a lobed and toothed blade. The small heads of flowers have short peduncles; groups of two or three heads terminate the stem and the various branches.

Reproduction.—At maturity—soon reached—the achene fruits are found within the cylindrical involucre of each head. For rapid dispersal each fruit is crowned with numerous long white pappus hairs. The involucre opens, the hairs spread out and are wafted by the wind carrying the achenes. These soon settle down and immediately produce a new brood. So rapid is development that three or more generations may be produced in a single season. For this reason Groundsel is described as ephemeral. After fruiting the parent dies.

Eradication.—Prevent seeding by keeping the hoes busy.

Arable and Grass Land

11\. W. P. **White Ox-eye Daisy** (*Chrysanthemum Leucanthemum*).

Height.—2 to 24 in.

Flowering.—June to August. On all soils; most abundant on poor

Habitat.—Very common in meadows, pastures, temporary leys of clover and grass, arable land, hedgebanks, waste land, &c.

Habit of Growth.—This is a dark green almost glabrous plant with stem erect and simple or branched above. The ground leaves are obovate, tapering into a long petiole, and coarsely toothed; the stem leaves, narrow, sessile, and stem clasping, are deeply cut at the top, with a few teeth towards the base.

The flower-heads are nearly 3 in. across, with a white ray and yellow disc; they stand solitary on long peduncles at the summit of the stem and of its branches.

Reproduction.—At maturity the achene fruits are found within the saucer-shaped involucre composed of many overlapping bracts with narrow purple borders and tips. The achenes are shed to produce the new generation.

Renewal.—Underground there is a slender creeping stem (rhizome) extended by creeping branches, from which the new shoots grow up.

Description of the Achene.—This achene occurs as an impurity in commercial seeds of Red Clover and Italian Ryegrass. It is obovate, 2 mm. long by 1 mm. broad, not compressed, with white ribs outstanding on a dark ground; at the broad end there is a small, light brown projecting knob.

Eradication.—

1. Use pure seed to prevent introduction of the weed.
2. Cut the hay early to prevent seeding and spread.
3. Put sheep on early to graze the young shoots and rob the rhizome.
4. Enrich the land by judicious manuring.

12. Y. P. **Coltsfoot** (*Tussilago Farfara*).

Height.—4 to 10 in.

Flowering.—March to May. On all soils; heavy, calcareous, and damp preferred (calciphile).

Habitat.—Very common in fields and in pastures on poor stiff clays, also in waste land, sandy places, and gravel pits, along riversides, railway tracks, &c.

Habit of Growth for Reproduction.—For flower-bearing in spring, tufts of special shoots grow out of the ground, each component simple and erect without green leaves. The parts of this scape shoot are:

1. The somewhat slender peduncle.
2. Its numerous oblong scales entire and erect, arranged spirally.
3. The solitary terminal erect flower-head 1 to 1½ in. across when expanded.

Reproduction.—At maturity the fruits formed only by the ray florets are found seated on the flat pitted axis of the head enclosed within the involucral bracts. The fruit itself is a pale brown one-seeded achene,

which for dispersal bears at its summit a crown of numerous soft snow-white hairs two or three times as long as the achene itself. When the fruits are ready for dispersal the pappus hairs spread out all over the head and are wafted away by the wind carrying the fruits with them. Ultimately the achenes settle on the ground, and produce at *their own time and season* a new but widely dispersed brood of Coltsfoot plants.

Fig. 5.—Coltsfoot (*Tussilago Farfara*)

1, Disc floret with pappus; 2, ray floret; 3, fruit with pappus; 4, ground leaves; 5, scaly scapes.

Habit of Growth for Nutrition.—For this purpose, after the fruiting stage of the first heads has passed, tufts of leaves covered all over with loose, white, cottony hairs emerge from the ground. When the leaf is full grown it consists of a short petiole and a glossy green, roundish, heart-shaped blade 4 to 10 in. across with about seven ribs radiating from the base and diverging. The margin bears numerous short dark teeth with shallow scollops or concavities between and seven or more projecting angles, each angle corresponding to a projecting rib. Although the upper surface is now glossy green, the whole lower surface still retains the white cottony hairs and is snow-white. All the food manufactured by these large leaves goes to the upkeep of an extensive underground establishment (rhizome).

Renewal.—Underground there is a white, fairly thick, horizontally extended, creeping stem (rhizome) with long branches which can burrow deep and then grow upwards, becoming horizontal near the surface. Along the sides of this rhizome clumps or tufts of special scaly buds for renewing the flowering scapes make their appearance in spring. Other buds in distinct tufts are present for producing the green leaves later in the year.

Propagation.—Any small part of this underground stem left in the land can develop independently and become a new Coltsfoot plant on its own account.

Eradication.—

1. Dearth of water does not suit Coltsfoot, therefore drain if possible.

2. To deprive the rhizome of its food supply, remove the green leaves systematically whenever they make their appearance.

3. Growth of a shade crop, such as vetches, has similar exhausting effect on the rhizome.

4. Remove as much of the rhizome as possible, taking care that any pieces left in the land are attended to before they have time to extend their growth.

5. Prevent reproduction and spread by cutting down the flowering shoots quite early in spring before any green leaves appear, at so young a stage that they cannot possibly mature the fruit.

Grass Land

13. W. P. **Daisy** (*Bellis perennis*).

Height.—2 to 8 in.

Flowering.—March to October. On all soils.

Habitat.—In pastures, often too plentiful.

Habit of Growth.—The Daisy is bright green and sparingly hairy. The short stems—of which there are many—bear spoon-shaped leaves so closely packed together by excessive shortening of the stem internodes that the whole shoot takes the form of a rosette with leaves spread horizontally on the ground.

From the axils of these leaves simple naked scape peduncles, bearing a solitary terminal flower-head with a white ray and a yellow disc, grow out.

Reproduction.—The head in fruit is constructed of a green involucre surrounding a short conical axis bearing numerous small, compressed, whitish achenes, which are readily shaken off and dispersed to some distance by the wind. Shed on the ground these achene fruits await their opportunity for producing a new brood of Daisies.

Renewal.—Underground there is a slender creeping brownish stem (rhizome), extended by branches which terminate by forming new rosettes of green leaves on the ground.

Eradication.—Encourage luxuriant growth of the surrounding herbage sufficient to cut off the light supply from the leaf rosettes. If this shading is continued the rhizome becomes exhausted, and the Daisies disappear.

14. Y. B. (or P.). **Ragwort** (*Senecio Jacobæa*).

Height.—1 to 4 ft.

Flowering.—June to September. On all soils; light, medium, and calcareous preferred.

Habitat.—Very common in pastures, field borders, on roadsides, and waste land.

Habit of Growth.—Ragwort is an almost glabrous deep green plant which during the first year produces a rosette of ground leaves with central bud and a long tap-root. The ground leaf has a short petiole and a long midrib in a lobed and toothed blade. The end segment of the blade is followed by large segments which dwindle in size as the petiole is approached.

During the second year the hard tough leafy stem develops (often flanked by extra stems), simple and erect at the base, with branches from the upper part lengthened to a degree sufficient to bring all the summits to a common level with the stem itself.

Fig. 6.—Ragwort (*Senecio Jacobæa*)
1, Disc floret; 2, plant in flower; 3, stigmas; 4, part of tap-root; 5, ray floret.

The stem leaf without petiole has a single midrib in a much divided ragged-looking blade curled like parsley and clasping the stem by its base.

The flower-heads are very numerous, in groups of separate compact corymbs, which taken together form the broad flat floral region at the summit of the plant. The single head is ¾ to 1 in. across the ray.

Reproduction.—At maturity the cylindrical achenes are seated on the axis of the head within the surrounding involucral scales. For dispersal each fruit bears its own pappus crown of long white simple hairs which, wafted by the wind, carry away the achenes and land them on the ground widely dispersed and ready at convenient opportunity to produce a new brood of Ragwort.

Renewal.—The rosette of leaves is developed from the fleshy underground stem (rhizome) which forms the termination of the tap-root. Often the rhizome is exhausted and dies after the production of the first bearing stem. At other times the rhizome appears to retain its power of renewing the plant—then the Ragwort is perennial.

Eradication.—

1. Prevent seeding and spread by early cutting.

2. Advantage is taken of the circumstance that grazing sheep readily eat out the bud in the centre of the rosette, whereas browsing cows leave the Ragwort untouched. Accordingly the simplest means of exterminating is to graze the land with sheep in the early part of the year. On land regularly stocked with sheep not a single Ragwort can be seen.

Natural Order, Compositæ—Thistle Type.

Juice watery. Spiny plants except Hardheads and Cornflower.

Arable Land

15. B. A. **Cornflower** (*Centaurea cyanus*).

Height.—1 to 2 ft.

Flowering.—June to August. Usually on poor sandy and gravelly soils overlying chalk.

Habitat.—Common in cornfields.

Habit of Growth.—The covering of loose cottony down is a conspicuous feature. The stem grows up simple and erect from a slender tap-root, with lanceolate leaves, usually toothed or lobed. The upper part bears leaves linear and entire, and develops a few long ascending branches. The pedunculate flower-heads terminate the stem and its branches. The involucre bracts have a characteristic fringe of silvery or fawn-coloured teeth. The individual flowers of a head are of two kinds: (1) the long blue trumpet-shaped flowers of the ray which are destitute of sexual organs and merely attractive; (2) the central purplish flowers equipped with all the organs requisite for reproduction.

Reproduction.—The fruits within the protecting involucre are one-seeded achenes with a lateral scar on the basal part, and crowned above with stiff reddish hair. These fruits are shed to produce the new brood; then the plant dies completely—it is an annual.

Eradication.—Spring cultivation and free use of the hoe suffice.

Fig. 7.—Spear Thistle (*Carduus lanceolatus*)

1, Fruit with pappus; 2, plant in flower; 3, floret; 4, pappus feather.

16. Pu. B. **Spear Thistle** (*Carduus lanceolatus*).

Height.—2 to 4 ft.

Flowering.—July to August. On all soils.

Habitat.—Common in pastures and on roadsides, in fields, and waste land, &c.

Habit of Growth.—During the first year a stout tap-root is developed in connection with a short stem bearing a rosette of ground leaves. Each leaf is 6 to 12 in. long, has a long midrib in a blade rough with a clothing of bristle hairs on its upper surface. This blade is attenuated at the base, and divided into segments with long stout spiny points.

During the second year the large central bud in the rosette grows up,

becoming a stout erect furrowed and woolly stem with narrow spiny wings which are direct continuations of the spiny stem leaves. The flower-heads are few but large, ¾ to 1½ in. across, borne singly on spiny peduncles which terminate the stem and branches. The involucre bracts are specialized for protection, each with a long bayonet-like tip.

Reproduction.—At maturity the achene fruits are found enclosed within the involucre. For dispersal the apex of each achene bears a crown of long hairs branched into feather form called "thistle down". The involucre opens, the feathers unfold, and the wind wafts the "down" away, carrying the fruits as passengers. The achenes, now widely dispersed, settle down, and form a new brood of Thistles to replace the parent now exhausted and dead from fruit-bearing.

Description of the Achene.—This achene without its pappus sometimes occurs in grain. It is compressed and egg-shaped, 3½ mm. long by 1½ mm. broad, with a rounded knob at the broad end; the surface is somewhat glossy grey and streaked with dark lines.

Eradication.—

1. Prevent introduction of the Thistles by keeping the surroundings clear and by sowing pure seed.

2. Prevent seeding by early cutting, remembering that *the ripening process continues* after the Thistles are cut.

Fig. 8.—Creeping Thistle (*Carduus arvensis*)

1, Male plant floret; 2, pappus feather; 3, female plant in fruit; 4, male plant in flower; 5, fruit with pappus; 6, leaf.

Arable and Grass Land

17. Dull Pu. P. **Creeping Thistle** (*Carduus arvensis*).

Height.—1 to 4 ft.

Flowering.—Late July to September. On all soils.

Habit of Growth.—This is a bright green almost glabrous thistle which grows up in patches of elongated barren shoots, and erect leafy stems without spiny wings, bearing numerous flower-heads ½ to 1 in. across when expanded, arranged as loose corymbs terminating the stem and its branches. The leaves are narrow, pinnatifid, and spiny to the very base, which either clasps the stem or runs down for a short distance. This thistle separates the sexes. On the male plant the heads are nearly globular with very projecting florets; on the female the heads are longer and the flowers scarcely project beyond the involucre.

Reproduction.—At maturity plenty of thistle down is seen within the

heads of the male plant, but no achene fruits. When, however, the heads with the long involucres are pulled open, numerous smooth dark oblong achenes are found, each crowned with its own pappus of feather hairs for dispersing the achene. Wafted away by the wind, these fruits settle down on fresh territory where a new and widely dispersed brood of Thistles is produced.

Renewal.—Underground and deep there is a white horizontal stem (rhizome) nearly as thick as a goose quill, undergoing constant extension to new areas by the formation of long horizontal rooting branches. The buds connected with this rhizome grow up above ground and renew there the barren shoots and the fertile flowering stems.

Propagation.—Any isolated part of this rhizome left in the ground has all the equipment necessary for the formation of a new plant on its own account.

Eradication.—

1. Prevent seeding and spread by early cutting.
2. Exhaust the deep extended rhizome by cutting off the shoots early and late as they appear; this cutting carried out systematically for two seasons suffices to rid the grassland of this pest.
3. Take a couple of root crops in succession, and keep the hoes going.

Grassland

18. Pu. P. Stemless Thistle (*Carduus acaulis.*)

Height.—2 to 6 in.

Flowering.—July to August. An indicator of lime on dry calcareous sandy and gravelly soils.

Habitat.—Pastures, especially chalk downs in the south of England.

Habit of Growth.—This is a rigid spiny plant, almost glabrous with dark glossy green leaves. All that appears above ground is a rosette of leaves spread flat on the ground with a radius of 1 to 1½ ft.; seated in the centre is a solitary ovoid flower-head, about 1 in. across.

Fig. 9.—Stemless Thistle (*Carduus acaulis*)

Reproduction.—At maturity the achenes for reproduction, crowned with a pappus of very long silky feather hairs for dispersal, are found within the involucre. The feathers spread out in the wind and scatter the achenes over a whole neighbourhood which soon becomes populated by the Thistle brood.

Renewal.—Underground a short woody stem (rhizome) with slender fibrous roots is developed for the express purpose of forming a new rosette with a central flower-head.

Eradication.—Spud early to prevent seeding; after spudding carefully apply a pinch of sulphate of copper to the cut surfaces.

19. Pu. P. **Black Knapweed** (*Centaurea nigra*).

Height.—6 to 36 in.

Flowering.—June to September. A calciphilous plant, i.e. preferring calcareous soil.

Habitat.—Very common in grass, meadows, pastures, field borders, on roadsides, &c.

Habit of Growth.—This is a spineless plant, rather rough with short hairs. A small tuft of stems, erect and hard, grows up. These bear alternate leaves, the lower with petioles and coarse-toothed blades, the upper entire and sessile, clasping the stem. From the axils of the upper leaves a few short stout erect branches are produced. The flower-heads before they expand appear as hard dark brown globular knobs about ½ in. across, seated singly on the thickened leafy extremities of the stem and its branches. On expansion numerous purple flowers project beyond the dark involucre bracts.

Reproduction.—At maturity achenes, usually without pappus, are found within the involucre; these achenes, becoming detached from the axis of the head, are shed upon the ground to produce a new brood.

Renewal.—For this the plant keeps underground a stout shortly creeping stem (rhizome) with short branches from which the loose tuft of air shoots is formed.

Eradication.—

1. Cut early to prevent seeding.
2. Hand pull in damp weather to remove as much of the rhizome as possible.
3. Encourage the grasses by judicious manuring.

NATURAL ORDER, COMPOSITÆ—DANDELION TYPE.

Juice milky. No spines (except Sowthistles).

ARABLE LAND

20. Y. P. **Corn Sowthistle** (*Sonchus arvensis*).

Height.—3 to 4 ft.

Flowering.—August to September. On all soils; damp preferred.

Habitat.—Common in cornfields, arable land, waste places, on banks of ditches, &c.

Habit of Growth.—This is an almost glabrous plant with much milky juice. Small tufts of ground leaves appear, and erect thin angular stems, succulent and hollow, bearing alternate leaves but no branches except those concerned in the formation of the terminal floral region.

The lower leaves have a long midrib in a narrow blade glossy above, with pointed lobes and fine spiny teeth along the whole margin. The upper leaves clasp the stem with the cordate base and have no lobes.

The flower-heads, 1 to 2 in. across when expanded, are pedunculate, one at the summit, and others on special lateral branches, all with involucres more or less clothed with glandular hairs.

Reproduction.—At maturity the fruits are formed within the involucre. They are achenes with a crown of copious white silky hairs which, wafted away by the wind, disperse the achenes far and near for the production of a new brood.

Renewal.—Underground there is a white fleshy creeping stem (rhizome) which becomes extensive by the formation of long creeping underground branches from which the tufts of leaves and the erect stems take their rise.

Propagation.—Any small piece of this rhizome detached in the ground suffices to develop a new plant.

Fig. 10.—Corn Sowthistle (*Sonchus arvensis*)

1, Ligulate floret; 2, achene with pappus; 3, rhizome; 4, plant in flower.

Eradication.—

1. Prevent spread by "seed".
2. Free use of the hoe in two or three root crops exhausts the rhizome.
3. This weed disappears from land laid down to grass for a few years.

21. Y. A. **Nipplewort** (*Lapsana communis*).

Height.—1 to 3 ft.

Flowering.—July to September. On all soils; loam and clay preferred.

Habitat.—Common on cultivated and waste ground, in clover leys, &c.

Habit of Growth.—From a fibrous tap-root the slender leafy stem grows up erect and forms upper ascending branches, branch growing out from branch. At the base the glabrous leaves are lyrate and serrated with a long midrib; the terminal segment of the blade is large and ovate, the lateral segments small and standing out from a narrow strip of blade. The leaves on the upper branches are narrow and entire. The penduneulate flower-heads terminate the numerous branches; they are small, $\frac{1}{4}$ to $\frac{1}{2}$ in. across, with oblong glabrous involucres.

Reproduction.—At maturity the achene fruits are found within the involucre. There are here no pappus hairs for dispersal; the achenes simply tumble out on to the ground. The plant then dies, but the achenes are left to produce a new and numerous brood.

Description of the Achene.—This achene is sometimes found among

Red Clover and other seeds; it is narrow and obovate or club-shaped, 4 mm. long by 1 mm. broad, brownish yellow, with numerous lighter coloured longitudinal strips.

Eradication.—Prevent seeding by thorough cultivation and free use of the hoe; hand pull any plants noticed.

Grass Land

22. Y. P. **Rough Hawkbit** (*Leontodon hispidus*).

Height.—6 to 12 in.

Flowering.—June to September. On all soils; dry, calcareous, sandy, and gravelly preferred.

Fig. 11.—Rough Hawkbit (*Leontodon hispidus*)

1, Rhizome, ground leaves, and scapes; 2, scape; 3, ligulate floret.

Habitat.—Common in poor pastures and heaths.

Habit of Growth.—This plant is pale green, rough, and often hoary from the abundance of white hairs. Many tufts of ground leaves are produced. The leaf from 2 in. to 1 ft. long is coarsely toothed. From a tuft of leaves one or more flower-heads grow out, each borne on its own scape peduncle which is thickened below the head; the involucre is composed of narrow scales with rough hairs.

Reproduction.—At maturity the numerous achene fruits are found within the involucre. Each achene is ½ in. long, spindle-shaped, and pale brown with a brownish white crown of feather hairs as long as the achene itself. For dispersal the involucre opens wide; then the feather hairs spread out and are wafted away by the wind, carrying the achenes with them to produce far and wide a new brood.

Renewal.—Underground there is a stout fleshy shortly creeping stem (rhizome) seemingly bitten off at the posterior end, but anteriorly bearing many short branches from which the tufts of ground leaves are renewed.

Eradication.—

1. Prevent the spread of the achenes by using the spud regularly and persistently.
2. Enrich the land by judicious manuring.

23. Y. P. **Autumnal Hawkbit** (*Leontodon autumnalis*).

Height.—3 to 24 in.

Flowering.—July to October. On all light dry soils.

Habitat.—Very common in meadows and pastures.

Habit of Growth.—Very like long-rooted Cat's Ear. The leaves, however, are glabrous and lack the numerous rough hairs so characteristic of the Cat's Ear; in outline they are long and narrow, with a few narrow lateral lobes. The flower-heads are so narrow at the base that they appear continuous with the peduncles, and the individual flowers of the head are not separated by special scales (bracts or paleæ)—a feature distinguishing it from Cat's Ear.

Reproduction.—The fruit has no beak, and is constructed of pointed achene with a crown of brown feather hairs for securing wide dispersal.

Renewal.—From a rhizome with a basal scar, marking the spot from which the tap-root has decayed away, the ground leaves are renewed.

Eradication.

1. Spudding, regular and persistent, will reduce.
2. Attempts may be made to encourage luxuriant growth of the surrounding herbage to shade the ground leaves of the Hawkbit.

24. Y. P. **Long-rooted Cat's Ear** (*Hypochœris radicata*).

Height.—6 to 18 in.

Flowering.—June to September. On all soils; dry preferred.

Habitat.—Very common in pastures, fields, and waste land.

Habit of Growth.—A rosette of spreading leaves rough and bristling with hairs appears on the ground. The leaf is blunt pointed, and along the margins segments of circles seem to have been cut away between the lobes. From the leaf axils several branching glabrous scapes grow out, each bearing two, three, or more flower-heads, one at the apex of the scape and one at the end of each branch. Immediately below the flower-heads there are small scale leaves borne on the specially thickened hollow ends of the peduncles.

Reproduction.—The fruit is formed within the near-by glabrous involucre, and subtending each fruit there is a narrow-pointed membrane scale (the floral bract or palea). The fruit, like that of the Dandelion, is constructed of: (1) a reddish brown spindle, the achene fruit proper; (2) a narrow continuation of its apex, the beak; and (3) a terminal crown of hairs—in this case branched hairs, i.e. feathers, not simple hairs as in the Dandelion. The involucre bracts spread out, the feathers unfold, and the wind wafts them away, widely dispersed, to new territory, where the achenes settle down and produce a new generation.

Renewal.—For this there is a long tap-root with a short stem (rhizome) as its crown, from which the leaves of the rosettes and the axillary scapes are developed and renewed.

Distinctive Feature.—When the flowers are pulled out of the head, each is found to correspond to a special pointed scale (the subtending bract).

Eradication.—

1. Prevent dispersal of the achenes.

2. Regular and persistent spudding will exhaust the underground parts and prevent the spread.

25. Y. P. **Dandelion** (*Taraxacum dens-leonis*).

Height.—4 to 12 in.

Flowering.—March to October. On all soils.

Habitat.—Very common in meadows, pastures, &c.

Habit of Growth.—Here there is a tufted rosette of ground leaves, sometimes solitary, sometimes several rosettes intermingled. From various leaf axils simple hollow scapes, each ending in a single involucrate flower-head, grow out.

Reproduction.—At maturity the numerous dry fruits are found within the inner part of the green involucre attached to the flat pitted axis of the head. Each fruit is constructed of: (1) the spindle-shaped achene containing one seed affixed to its base; (2) the elongated slender cylindrical beak; and (3) the crown of white simple hairs (pappus) which is the calyx of the flower now enlarged. When the fruits are ready for dispersal the involucre becomes reflected on the peduncle; the pappus hairs open out and fly away in the wind carrying with them the beak and the achene fruit at the base. Ultimately the achenes, widely dispersed, colonize new land and produce there a brood of Dandelion plants.

Renewal.—Underground there is a long fleshy vertical tap-root passing insensibly upwards into its stout crown of underground stem (rhizome), which may be simple or bear a few short branches. From this crown stem the ground leaves of the rosette are renewed; and, if the crown has branches, a rosette originates from each branch. Next year to replace the dead leaves the same rhizome bears a new rosette higher up, next year still higher up, and so on. Nevertheless the leaves are always produced at the ground. This is explained by the contraction of the tap-root below, which year by year pulls the lengthening crown deeper into the ground.

Propagation from the fleshy tap-root. Renewal of the Dandelion is not prevented by spudding off the rhizome part. Any part of the tap-root left behind in the ground can produce adventitious buds, and a corresponding crop of slender vertical underground scaly stems, each of which forms its own rosette of leaves and its own roots. The total effect of the removal of the rhizome is accordingly the virtual production of many plants instead of one.

Eradication.—

1. Prevent Dandelions in the neighbourhood from maturing their fruits and dispersing them over the land.

2. Attack repeatedly by means of the spud to remove the rhizome and to exhaust the storing tap-root.

NATURAL ORDER, CONVOLVULACEÆ.

Non-parasitic green plants. Stem twining. Leaves alternate without stipules. Flowers large and conspicuous.

ARABLE LAND

26. Pk. P. **Lesser Bindweed** (*Convolvulus arvensis*).

Height.—6 to 30 in.

Flowering.—June to August. On all soils; heavy preferred.

Habitat.—Very common in cornfields, cultivated and waste land, on roadsides and hedgebanks, &c.

Habit of Growth.—Numerous slender stems grow out in a loose tuft and trail along the ground to a distance of 1 or 2 ft. If, however, a suitable support plant is growing in the neighbourhood, the trailing habit ceases, and to get better access to light the twining habit is adopted. The Bindweed ascends along a spiral line on the support, twining against the sun in a counter-clockwise direction, and as it goes round bearing the alternately disposed petiolate leaves with a broad arrow-shaped blade. From the leaf axils solitary peduncles grow out, each ending, it may be, in a large solitary flower 1 in. across, or in a cymose group of two to four flowers.

FIG. 12.—Lesser Bindweed (*Convolvulus arvensis*)
1, Stamen; 2, plant in flower; 3, gynæcium.

Reproduction.—At maturity within the persistent calyx the dry globular fruit about the size of a pea is found; within the fruit case are four seeds with basal attachment, separated in twos by a thin partition. To set the seeds free the fruit, now on a hanging pedicel, forms two longitudinal fissures through which the four seeds escape and fall separately upon the ground to produce the new generation.

Renewal.—Deep in the ground, and capable of descending more deeply as circumstances allow, there is a slender underground stem (rhizome) from which long creeping branches grow out horizontally and extend the underground growth in various directions. From this rhizome the renewal shoots grow up into the light. Any piece left in the ground can propagate and form a new plant.

Properties and Description of the Seed.—This seed is poisonous and may occur in all kinds of grain. It is three-faced and pointed at one end, with a hard rough skin which is reddish brown, almost black. When crushed in water the contents form a soapy lather.

Eradication.—

1. Deep ploughing and collecting the rhizomes with harrows is useful.
2. When small patches occur fork them out.
3. Continuous removal of the young shoots exhausts the rhizome and ultimately kills the plant.

NATURAL ORDER, CONVOLVULACEÆ.

Twining parasite destitute of chlorophyll and of leaves; no connection with the soil. Parasitic weed on clover.

27. W. A. **Clover Dodder** (*Cuscuta trifolii*).

Height.—12 to 36 in.
Flowering.—August to September. Not connected with the soil.
Habitat.—Rooted in the stems of Red Clover plants.
Habit of Growth.—The stem is branched and quite thin, like a reddish yellow thread, destitute of leaf and chlorophyll. This thread is wound round the clover host, following a spiral course. As it winds, special roots grow out and penetrate into the food-containing tissues of the clover stem, exploiting and absorbing therefrom all the food and drink required to maintain their rapid growth.

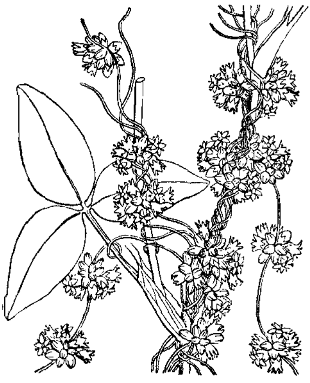


Fig. 13.—Clover Dodder (*Cuscuta trifolii*)

Catching a New Host and Propagation.—When the first plant preyed upon has been exhausted, the tip of a slender thread grows out and revolves in a circular direction. As soon as a new plant is touched the twining again begins, and sucking roots again penetrate to the food and drink supplies of the clover. When this second host is exhausted the revolving is repeated and another new host is caught. In this way many clover plants are caught and killed by a single Dodder parasite.

Flowering.—About the end of July flowering begins; all the resources of the parasite are expended in the production of numerous compact globular heads of small flowers which make their appearance at intervals, seated along the stem.

Reproduction.—At maturity the flower forms within its persistent calyx a dry globular fruit containing four seeds affixed at the base and separated in twos by a thin partition. To allow these seeds to be scattered the top part of the fruit detaches transversely as a lid and the seeds fall out. When clover infected with Dodder is harvested for seed the yield is a mixture of clover and Dodder.

Flowering and reproduction utterly exhaust the Dodder—it is an annual.

Description of Seed.—This seed is somewhat globular, 1 to 1·2 mm. in diameter, with three blunt angles; the surface is dull, greyish yellow or brown, like a particle of earth. The embryo within is a thread-like body wound several times round the endosperm, destitute of cotyledon, although a member of the Dicotyledon class.

Catching the First Clover Host.—When a mixture of clover and Dodder seeds is sown, young clover plants and young Dodders are produced. To form the Dodder seedling one end of the thread embryo grows down into the ground, the other elongates upwards, and using the root as a pivot begins to revolve in the air like a blind man groping for something. If a young clover plant comes in its way, the thread begins to twine and makes a few turns round the stem of the clover and inserts its first sucking root into the stem. Now the primary pivot root dies away, and the Dodder has become a complete parasite with roots in a living host, none in the soil.

Eradication.—

1. Use clover seed free from Dodder.
2. If the clover is already infected the infected plants should be dug out and burnt.
3. No pieces of Dodder should be left behind to mature seed and spread the infection.

NATURAL ORDER, CRUCIFERÆ.

Leaves in rosettes, or alternate, without stipules.

ARABLE LAND

28. Y. A. **Charlock** (*Brassica sinapis*).

Height.—1 to 2 ft.

Flowering.—June to August. On all soils; prefers heavier types. Runch favours lighter land.

Habitat.—Very common in cornfields and arable land—a follower of the plough.

Habit of Growth.—This plant closely resembles Runch; the leaves are much less divided; the sepals spread horizontally and not vertically; and the petals are bright yellow without lilac veins.

Reproduction.—In this case the pod opens by two valves which detach

from the base upwards and fall away, leaving the seeds exposed and attached by their stalks to a special frame. The naked seeds, shaken away from their stalks before the cereal fruit is cut, fall separately to the ground for the purpose of producing a new generation. After fruit-bearing the whole plant dies—the plant is an annual.

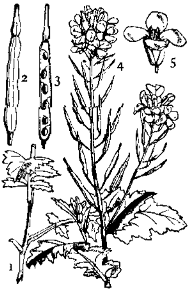


Fig. 14.—Charlock (*Brassica sinapis*)

1, Shoot base; 2, fruit; 3, fruit showing seeds; 4, shoot in flower and fruit; 5, flower with spreading sepals.

Description of the Seed.—This seed sometimes occurs as an impurity in grain and in turnip seeds. It is globular, $1\frac{1}{4}$ to $1\frac{1}{2}$ mm. in diameter, with a dark reddish brown skin; very like turnip seed, but slightly smaller. When chewed tastes of mustard—not bland and oily.

Vitality of the Seed.—When old pasture land is broken up Charlock plants often appear in abundance. Apparently seeds have remained buried and dormant in the pasture land. When brought to the surface the ancient seeds germinate and reproduce a brood of Charlock weeds where apparently no Charlock has been before. A similar remark as to vitality of seed applies to Runch.

Eradication.—See *Runch.*

29. Y. A. Wild Radish or Runch (*Raphanus Raphanistrum*).

Fig. 15.—Wild Radish (*Raphanus Raphanistrum*)

1, Seed; 2, jointed fruit with cylindrical beak; 3, embryo; 4, shoot in flower and fruit; 5, flower with erect sepals; 6, shoot base.

Height.—1 to 2 ft.

Flowering.—June to July. On all soils; light preferred.

Habitat.—Very common in cornfields and arable land.

Habit of Growth.—This plant is rough with short bristly hairs. From the slender tap-root the branched stem grows up erect. At the ground a few leaves are produced; these are lyrate with six or seven distant lateral segments. The leaves subtending the branches are simplified, with a large end lobe and two well-marked lobes below (distinction from Charlock). The flowers form racemes, terminating the stem and its branches. The individual flower, about $\frac{3}{4}$ in. across, has four vertical sepals and four pale yellow petals with lilac veins.

Reproduction.—At maturity the fruit is quite naked, like a row of four to eight green beads

terminated by a slender cylindrical beak or style. For dispersal the pod breaks transversely into closed one-seeded pieces (mericarps); sometimes the whole pod detaches from its stalk. Each mericarp can produce a new Runch plant. After bearing, the whole plant dies, exhausted—it is an annual.

Description of the Mericarp.—The mericarps of Runch often occur in grain, and are readily mistaken for harmless pieces of straw. The form is barrel-like, 3 mm. long, 2 mm. broad, with flat ends; the surface is ribbed and straw-coloured; the single seed filling the barrel is oval and reddish brown.

Eradication.—

1. Do not sow seed containing Runch as an impurity.
2. By spring cultivation destroy the seedlings.
3. When the weed plants are still young in the corn, spray with a 4-per-cent solution of sulphate of copper at the rate of 40 gall. per acre; a second application of the spray may be advisable.

30. W. A. **Shepherd's Purse** (*Capsella bursa-pastoris*).

Height.—6 to 18 in.

Flowering.—February to November. On all soils; light preferred.

Habitat.—Very common in cultivated and waste land.

Habit of Growth.—From the crown of the tap-root a rosette of spreading ground leaves is produced. The component leaves have a long midrib in a blade usually lobed and pinnatifid. From the central bud of the rosette a solitary erect stem with long internodes, leaves, and branches is developed. The leaf is eared at the base and clasps the stem. Numerous small flowers about $\frac{1}{10}$ in. across, arranged in racemes, make their appearance at the ends of the stem and the leafy branches.

Fig. 16.—Shepherd's Purse (*Capsella bursa-pastoris*)

1, Tap-root, rosette, and erect stem; 2, opening fruit; 3, shoot in flower and fruit; 4, petal; 5, flower.

Reproduction.—At fruit-bearing the racemes elongate; now the naked triangular pods, broad at the top and $\frac{1}{4}$ to $\frac{1}{2}$ in. long, are found. Each pod contains twenty or more small oblong reddish brown seeds. For dispersal of these two valves detach; the seeds are now naked and suspended by stalks from the narrow frame left standing when the two valves fall away; when shaken from their stalks to the ground they produce a new brood. After seed production the whole plant dies—it is an annual.

Diseases.—Shepherd's Purse is often found affected by two fungoid diseases which attack crops: (1) finger-and-toe of turnip and swede (the finger-and-toe fungus is also harboured by Runch and Char-

lock when no turnips are in the ground); (2) white rust of cabbages.

Eradication.—Spring cultivation and free use of the hoe in the root crop tend to eradicate this annual weed.

Grass Land

31. Li. P. **Cuckoo-flower** (*Cardamine pratensis*).

Height.—1 to 2 ft.

Flowering.—April to July. On moist and marshy land.

Habitat.—Grassland.

Habit of Growth.—This plant is glossy and almost glabrous. Rosettes or tufts of leaves emerge from the ground. The ground leaf has a very short petiole and one long midrib in the narrow blade, divided into a large terminal leaflet, and five or more pairs of lateral leaflets, all roundish in outline and scarcely toothed on the margin.

Fig. 17.—Cuckoo-flower (*Cardamine pratensis*)

1, Stamens and gynæcium; 2, petal; 3, inflorescence; 4, rhizome, rosette, and erect stem.

From the centre of the rosette the erect slightly zigzag leafy stem grows up; sometimes several stems are formed by basal branching of the main stem—then the growth is erect and tufted. These stem leaves are divided into leaflets, which are not round but narrow and lanceolate. The flowers, $\frac{1}{2}$ to $\frac{3}{4}$ in. across, form a short terminal raceme. In this flower the anthers are yellow and deep down within the corolla.

Reproduction.—At maturity the narrow cylindrical pods, over 1 in. long, stand naked on their pedicels. To scatter the seed two valves suddenly detach from below, curl up, and jerk out the seeds with explosive violence, thus making provision for the production of a new brood at some distance away from the parent plants.

Propagation.—In wet seasons small bulbs are produced from the base of the stem; each of these bulbs can become an independent plant. Sometimes adventitious buds are developed from the leaves; these buds become detached and are scattered around to make new plants.

Renewal.—Underground there is a short, stoutish, creeping stem (rhizome) densely clothed with root-fibres. From the apex of this rhizome leaf tufts and leafy stems are renewed.

Eradication.—

1. Drain.
2. Manure to encourage better herbage.
3. Cut down early to prevent seeding and spread.

Natural Order, Equisetaceæ.

Whorls of branches; reproduced from spores—no seed production.

Arable and Grass Land

32. P. **Field Horsetail** (*Equisetum arvense*).

Height of barren stems, 1 to 2 ft.; of fertile spore-bearing stems, 3 to 6 in.

Spore-bearing.—April. On all damp soils.

Habitat.—Very common in cultivated ground, waste places, field borders, roadsides, railway banks, &c., and at times in grass land.

Habit of Growth. — The Horsetail develops two kinds of stems: (1) the short-lived spore-bearing or fertile stems solely for spore production and destitute of chlorophyll — in spring these appear as tufts; (2) the solitary barren stems with chlorophyll, solely for food manufacture—these appear after the fertile stems are dead, and last till autumn.

Reproduction by fertile stems. These rise erect out of the ground and are only 3 to 6 in. high. They are whitish, succulent, fairly stout, unbranched, and hollow, with a terminal pale brown obtuse spore-bearing cone $\frac{3}{4}$ to $1\frac{1}{2}$ in. long. For spore scattering there is a double arrangement. (1) The spore bags burst open explosively and eject the spores. (2) Each green spore has special "elaters" which are hygroscopic, and keep the spore constantly on the move till a damp place is reached; then the spores come to rest, germinate, and begin to produce a new generation of Horsetails. After spore-bearing the fertile shoots die down.

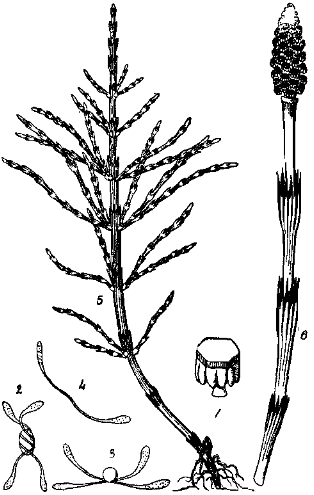


Fig. 18.—Field Horsetail (*Equisetum arvense*)

1, Scale from cone with spore bags; 2, spore, partly dry; 3, dry spore with spread elaters; 4, elater detached; 5, barren shoot; 6, fertile shoot.

The Barren Stems.—These rise erect out of the ground; they are slender and rough, bearing elongated simple branches arranged in whorls of three to six. The top part of the stem with its branches has the form of a green pyramid. On cultivated land the stems may grow prostrate along the ground with the branches more elongated and fewer per whorl.

Renewal.—Deep underground, it may be 3 ft. down, there is a thin root-bearing slender solid dark-coloured stem (rhizome) extended by long branches in all directions. From the more superficial branches of this rhizome the tufts of fertile stems are renewed in the spring; later the lasting green barren stems make their appearance.

Propagation.—At the internodes of the rhizome the absorbing adventitious roots are produced, and sometimes at the same point short thick stems of a single internode make their appearance. These small tubers, corresponding to the large tubers of a potato, are special propagating organs; from each one of them a new and independent Horsetail plant may be developed.

Further, branches of the rhizome cut into small pieces with a plough or otherwise suffice to propagate and produce plants corresponding in number to the pieces.

Eradication.—

1. This is a moisture-loving plant (hygrophilous); therefore drainage will reduce this weed.
2. Prevent reproduction and spread by attending to the fertile stems early in the year, so that no spores are allowed to be sown on the ground.
3. Endeavour to exhaust the rhizome by regularly and persistently removing the green stems.

NATURAL ORDER, FILICES.

Reproduced from spores borne on green frond leaves; no seed production.

GRASS LAND

33. P. **Bracken** (*Pteris aquilina*).

Height of Frond.—2 to 6 ft.

Spore-making.—July to August. On light soils, dry or moist but not swampy.

Habitat.—Very common on heaths, moors, upland pastures, wood margins, &c.

Habit of Growth.—The leaves (or fronds) with long petiole emerge erect and solitary from the ground. The blade is of broadly triangular outline divided and redivided into lanceolate blunt segments, light green, glabrous above and of leathery texture. The young fronds are rolled like a crozier and clothed with brown scaly hairs.

Reproduction.—For this purpose innumerable sporangia are developed,

each containing sixty-four green spores of microscopic size. These sporangia are clustered together in lines along the under margins of certain segments of the frond, usually the lower segments. The sporangia are doubly protected, for they lie under cover of a thin membrane itself covered by the reflexed margin of the frond. To disperse these enclosed spores the sporangia burst across with explosive violence, and the innumerable spores are scattered and shed at some distance all around for reproducing on the ground by the sexual process a brood of Bracken plants. In autumn, after spore dispersal, the frond becomes brown and dry and dead, leaving a living stump of the petiole behind in the ground attached to the underground stem.

Renewal of the Fronds.—Deep in the ground there is a dark horizontal stem (rhizome) as thick as the little finger, clothed with brown hairs at the apex. Behind this apex the young fronds in course of developing are found, and farther back the persistent stumps of the old petioles, arranged at a distance from one another and in two rows. Evidently the rhizome is the renewing apparatus.

Fig. 19.—Bracken (*Pteris aquilina*)

1, Rhizome with young frond; 2, leaf blade; 3, sporangia on fertile leaflet; 4, fertile leaflet.

Eradication.—

1. Cutting the fronds before spore-shedding prevents reproduction.

2. Repeat cutting while the fronds are still young, before they have repaid to the rhizome the cost of manufacture; this tends to exhaust the renewing apparatus.

A most effective and practical method has been devised by Captain Buchanan of Auchentorlie. He provided the boys of the village school with special golf clubs having a sickle for cutting instead of a head for striking. He set the boys to cut down the young fronds, which they did with much zest. This treatment repeated for two seasons caused the Bracken to disappear from exhaustion of its rhizome.

NATURAL ORDER, GERANIACEÆ.

Leaves stipulate, sometimes alternate, sometimes opposite. Lobed fruit with a long beak.

ARABLE AND GRASS LAND

34. Pk. A. **Dove's Foot Geranium** (*Geranium molle*).

Height.—6 to 12 in.
Flowering.—April to September. Light soils preferred.

Habitat.—Very common in dry pastures, cultivated and waste ground.

Habit of Growth.—The plant is clothed with soft white hairs and hoary green. From the crown of the tap-root numerous ground leaves are produced with very long petioles. The blade has seven or more ribs of equal length diverging from its base and a corresponding number of shallow segments, blunt and three-lobed at the apex. From the leaf axils a loose tuft of branched and spreading stems grow out, with leaves alternately arranged. Opposite to the leaves the pedicellate flowers appear in pairs terminating the peduncle. The flower is small, $\frac{1}{4}$ to $\frac{1}{2}$ in. across, with deeply cloven petals.

Reproduction.—See *Cut-leaved Geranium.*

In Dove's Foot the lobes of the fruit have an uneven surface with numerous transverse wrinkles but no hairs.

Description of Seed.—This is a common impurity in the small-seeded clovers, Alsike and White. The form is oval, $1\frac{1}{2}$ mm. long by 1 mm. broad, the surface reddish brown and smooth without pits.

Eradication.—

1. The plants may be removed by hand from clovers and rotation grasses to prevent seed contamination.

2. From the root crop they may easily be hoed out.

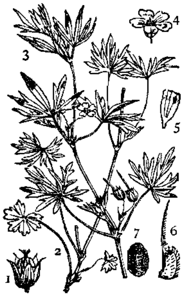


Fig. 20.—Cut-leaved Geranium (*Geranium dissectum*)

1, Flower (petals fallen); 2, base of plant; 3, plant in fruit; 4, flower; 5, petal; 6, *fruit lobe with beak*; 7, seed.

35. R. A. **Cut-leaved Geranium** (*Geranium dissectum*).

Height.—6 to 18 in.

Flowering.—June to August. On all soils, especially on heavier types.

Habitat.—Fields, clover leys, and hedge banks, very common.

Habit of Growth.—The plant is deep green *often tinged with red, and clothed with short stiff* hairs. From the crown of the tap-root the leaves on long petioles spread out. The blade has five ribs and corresponding segments, three to five-lobed, at the apex. Numerous stems grow out and spread along the ground. The leaves are opposite, with short stalks and blades of five narrow segments, three-lobed at the apex. The flowers are small, $\frac{1}{4}$ to $\frac{1}{2}$ in. across, in pairs, mostly on peduncles which are axillary; none are opposite to the leaves. At the flowering stage the ground leaves are withered and dead.

Reproduction.—At maturity the five-lobed five-seeded fruit is found within the persistent calyx, beyond which the long beak projects. The fruit lobes are hairy, with an even unwrinkled surface. For seed

dispersal, suddenly, with a jerk, the fruit lobes separate from the central axis, curl up like watch springs, and shoot the seeds away to a distance, leaving the coiled lobes standing empty. Seeds in abundance are thus sown to produce a new brood. After seed dispersal the whole plant dies—it is an annual.

Description of the Seed.—This is another common impurity in clover seeds. It is oval, 2 mm. long by $1\frac{1}{2}$ mm. broad, greyish green, with a surface pitted like a honeycomb.

Eradication.—

1. Sow pure seed.
2. Destroy the seedlings by cultivation.
3. Hand pull to prevent seeding.

NATURAL ORDER, GRAMINEÆ.[1]

ARABLE LAND

36. A. **Wild Oat** (*Avena fatua*).

Height.—3 to 4 ft.

Flowering.—June to July. On all soils not poor.

Habitat.—Cornfields and cultivated ground; quite rare in Scotland.

Distinction from Cultivated Oat.—

1. The spikelet is three-flowered and three-awned. The spikelet of cultivated oat has one awn at most.

2. The lower pale (flowering glume) is often brown when ripe, and is clothed with dark hairs especially at the base.

Fig. 21.—Wild Oat (*Avena fatua*)
1, Flower with pales; 2, panicle ear; 3, plant, lower part.

A. **Grey or Shetland Wild Oat** (*Avena strigosa*).

Height.—2 to 3 ft.

Flowering.—July to August. On all soils; most abundant in poor land, and in wet seasons; sometimes cultivated in Shetland.

Habitat.—In Scotland, frequent in cornfields.

Habit of Growth.—Many barren and some fertile shoots form a tuft.

Distinction from Avena fatua.—

1. The spikelet is two-flowered and two-awned.
2. The husk of pales is very thin.
3. The lower pale is without hair, and split at the apex into two bristle-pointed segments. Accordingly the spikelet may seem to have six awns.

Eradication.—

1. Sow pure seed.

[1] See article on PASTURE PLANTS, Vol. III.

2. *The root crop after an impure oat crop should be thoroughly cleaned.*

3. Sow a barley crop and remove the Wild Oats by hand.

Vitality of Seed.—The seed of Shetland Oat can lie dormant in the land, and at favourable opportunity may spring up in cultivated oats. This has led to the idea that cultivated oat can be transformed into Wild Oat.

37. P. **Pearl Grass** (*Arrhenatherum avenaceum*, var. *bulbosum*).

Height.—2 to 4 ft.

Flowering.—June to July. Confined to light land.

Habitat.—Very common in fields, field borders, and hedge banks.

Habit of Growth.—Several tufts of erect leafy shoots with long broad leaves grow up close together out of the ground. The fertile shoots of the tufts carry a slender nodding ear 6 to 10 in. long. The spikelets somewhat resemble those of cultivated oat; here, however, they maintain the erect position and do not hang down. A distinctive feature of Pearl Grass is seen along the straw—the thickened bases of the leaf sheaths are clothed with downy hairs. On cultivated Tall Oat (French Ryegrass) the corresponding parts are glabrous.

Reproduction.—Within each spikelet a single grain fruit is formed. For dispersal this grain has its thin light husk, and other buoyant accompaniments. When shaken out of the glumes it falls to the ground at some distance away from the parent plant, there to await opportunity for producing a new Pearl Grass plant.

Renewal and Propagation.—Underground there is a slender branched and creeping stem (rhizome) from which at appropriate season the various tufts of air shoots take their rise. The underground basal internodes of each of these shoots become chains of swellings, each swelling representing one internode. From the various tufts and their many shoots numerous chains and tufts of chains become clumped together into one large mass of swellings—readily detachable from each other. Each swelling—call it pearl, or corm, or tuber, or bulb as you will—is potentially a new plant.

Eradication.—

1. Remove the pearls. This is not easy; therefore great care must be taken that few pearls—as few as possible—be left in the ground.

2. When the pearls left behind show green shoots above the ground, remove as soon as possible by the hoe; use freely in the root crop.

3. Autumn cultivation is most useful; then the weeds should be picked out by hand. Exposure to winter frost and thaw kills much of the pest.

38. P. **Couch Grass** (*Agropyrum repens*).

Height.—1 to 4 ft.

Flowering.—June to August. On all soils.

Habitat.—Very common in arable land, waste ground, and hedges.

Habit of Growth.—Numerous elongated hair-clad shoots grow out of the ground. On these the leaf-blades are broad with a pair of claw-like hooks at the base, and the ligule is rudimentary.

The shoots of Agrostis (Bent Grass), on the other hand, are destitute of hairs, have no claws at the base of the leaf-blade, and the ligule is well developed.

The ear is constructed like that of wheat, but the glumes of the spikelets are narrow pointed.

Reproduction.—For this the grains are formed. Unlike wheat they do not escape naked, but are shed on the ground enclosed within their husks to produce a new generation of Couch plants from seedlings.

Renewal.—Underground a white horizontally extended and branched stem (rhizome) is developed. At each termination there is an elongated hard sharp-pointed scaly bud for the double purpose of extension, and of forming a new green shoot above ground. This bud is capable of boring its way through soil however stiff; specimens occur in which the bud has penetrated a potato tuber, entering at one side and emerging uninterrupted from the other. Buds can form at any node along the rhizome and grow up to form new green shoots.

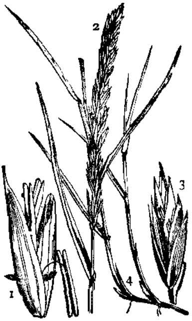


Fig. 22.—Couch Grass (*Agropyrum repens*)

1, Flower with pales; 2, ear; 3, spikelet; 4, rhizome with erect shoots.

Propagation.—If the rhizome is cut into pieces by agricultural implements or otherwise, each piece can produce a new plant on its own account. Accordingly, although the rhizomes of Couch are removed from the land and burnt, enough usually remains behind to propagate and form a new brood of plants which gradually build up extended rhizomes rooted in the ground. The piece left behind is the important thing to attend to.

Eradication.—

1. Couch is an arable land weed, therefore, like any other weed which is confined to arable land, it can be destroyed by laying the land down to pasture for a few years.

2. Bring as much of the rhizome as possible to the surface, gather, and burn. This is most easily accomplished by autumn cultivation.

3. Parts of the rhizome left behind may be caught early and destroyed by the use of hoe in the root crop.

39. A. **Soft Brome** (*Bromus mollis*).

Height.—1 to 3 ft.

Flowering.—May to August. On all dry soils.

Habitat.—Very common in temporary leys of grass, meadows, fields, waste ground, &c.

Habit of Growth.—This is a hairy grass with fibrous roots and a tuft of erect shoots all of which become fertile. The hairy leaf sheaths are split only at the apex, not all the way down; this peculiarity suffices to distinguish Brome from other hairy grasses. The ear is a panicle with large downy spikelets ½ to 1 in. long, many-flowered and short-glumed. A distinctive feature is found at the apex of the lower pale—a shallow notch with a projecting awn.

Reproduction.—At maturity the grain fruit is found enclosed within a husk of pales, one grain corresponding to each flower of the spikelet. For dispersal the axis of the spikelet disarticulates, and the now isolated husked grains with a segment of the axis attached are shed on the ground for producing a new brood. The parent plant now dies—it is an annual.

Occurrence of the "Seed".—Husked grains of Soft Brome are very common impurities in commercial grass seeds. Hay-loft sweepings are often composed of this along with Yorkshire Fog.

Eradication.—

1. Beware of hay-loft sweepings, and of dung to which such sweepings have been added.
2. Sow seed free from this impurity.
3. Prevent seeding by early cutting; the seeds are shed by the month of June.

This is one of the "seeds" that may lie dormant in the land and unexpectedly spring into renewed life when the circumstances are favourable. Because of this some people imagine that cultivated corn can change into Brome Grass.

Arable and Grass Land

40. P. **Common Bent** (*Agrostis vulgaris*).

Height.—12 to 18 in.

Flowering.—July to August. On all soils—not wet; rich and poor.

Habitat.—Most common in pastures, both lowland and upland, arable land, heaths, &c.

Habit of Growth.—On arable land, e.g. on a richly manured potato field, small tufts of barren shoots grow up from a rhizome closely resembling that of Couch. These Agrostis shoots cannot possibly be confounded with those of Couch if the base of the leaf-blade and the ligule

be looked at. On Couch leaf blades there are hairs, basal ears, and practically no ligule. On Agrostis, no hairs, rounded leaf base, and a well-marked ligule.

Reproduction.—At the end of a short slender straw there is a pyramid-shaped dark-coloured panicle of small spikelets $\frac{1}{12}$ in. long, one-flowered, and long-glumed. At maturity the flower develops a very small grain enclosed within a very thin membranous husk readily detachable from the glumes. When the straw is shaken by the wind, these enclosed grains are shaken off and strewn on the ground at a distance from the parent plant. In this way Bent Grass makes provision for the production of a new generation.

Renewal.—Underground, deep or shallow according to the circumstances of the case, a horizontal stem (rhizome) short or long, creeping and extending in all directions by the formation of branch stems, is produced. From this rhizome the tufts of shoots are renewed.

Propagation.—Small pieces of this rhizome left at rest in the ground are potent to develop new shoots, new rhizomes, new plants.

Eradication.—

1. If Bent Grass is abundant in a pasture, plough up, clean very thoroughly, and reseed.
2. In arable land treat as for Couch Grass.

41. P. **Yorkshire Fog** (*Holcus lanatus*).

Height.—1 to 2 ft.

Flowering.—June to August. On light land and moor land.

Habitat.—Very common in meadows, pastures, woods, hedges, moors, &c.

Habit of Growth.—This plant is clothed with soft and velvety white downy hairs. Tuft upon tuft, each of erect barren and fertile shoots, makes up the large cushion-like compound tuft of Yorkshire Fog. When an individual shoot is pulled out of the ground it is readily recognized by the abundant soft hair, and by the red tinted veins in the white basal part of the leaf sheaths. When in ear the panicle bears numerous flat white spikelets, $\frac{1}{8}$ in. long and half as broad. The glumes are long enough and broad enough to conceal completely all the parts within.

Reproduction.—At maturity each spikelet forms but a single grain, which at once gains protection, buoyancy, and means of dispersal by remaining enclosed within the spikelet. The whole spikelet readily disarticulates from its stalk, and when the ear is shaken by the wind its many spikelets are dispersed separately to a distance. At hay cutting many seeds are shaken off, and on the hay loft many more. From these seeds, when they get to the ground, the new broods of seedlings and plants are produced.

Renewal.—Underground there is a slender stem from which numerous

tough branches grow up to form the new tufts of green shoots at their summits.

Eradication.—

1. Do not contaminate the land by putting upon it seeds, &c., containing this impurity. Common sources are hay-loft sweepings and dung.

2. Very early cutting is necessary to prevent shedding of the Holcus seeds upon the land.

3. If Yorkshire Fog abounds in grass land, plough up, manure well, clean thoroughly, and re-seed with a mixture containing minimum amount of Ryegrass.

NATURAL ORDER, JUNCACEÆ.

Flowers very small and brown. Two types—leafless and leafy.

GRASS LAND

42. Br. P. **Common Rush** (*Juncus communis*): the leafless type.

Height.—1 to 3 ft.
Flowering.—July to August.
Habitat.—Very common in grass land.
Habit of Growth.—Above ground dense circular tufts of barren and fertile green stems are produced. These stems, often mistaken for leaves, are cylindrical, leafless, soft, and pliable, completely filled with a white compressible pith. Some of the stems end in a hard sharp point—these are barren. Other stems of the tuft are fertile with a single globular head of numerous small brown flowers placed laterally about 6 in. behind the pointed summit. In some forms of this rush the flowers are of a light fawn colour and more loosely packed; this form is called the Loose-flowered Rush.

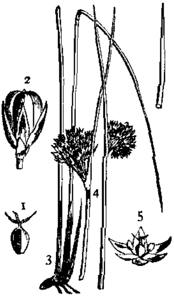


Fig. 23.—Common Rush (*Juncus communis*)
1, Gynæcium; 2, fruit with perianth; 3, rhizome with shoot bases; 4, fertile shoot; 5, flower.

Reproduction.—At maturity the bulging capsule fruit fills up the surrounding and persistent perianth leaves. Within the fruit case very numerous and very minute seeds have been formed. To allow dispersal three longitudinal valves open out, bearing the seeds attached to a partition extending along the middle line of each valve; when the wind blows, the minute seeds are shaken away and reach the ground at a distance. Thus adequate provision is made for the reproduction of brood upon brood of seedling rushes.

Renewal.—Underground there is a short horizontal creeping stem (rhizome) built up of numerous short horizontal branches growing out one from the other, bearing scales and elongated fibrous roots with absorbing hairs. From the axils of these numerous scales, equally numerous green stems grow up erect to form the compact circular tuft of green stems.

Eradication.—

1. The rush rhizome is so constructed that it cannot bear dry conditions for any length of time. Accordingly drainage of subsoil water will lead to the natural disappearance of rushes.

2. Cutting down systematically, especially when the green parts are young, will ultimately exhaust the rhizome and the rushes will die out.

43. Br. P. **Field Woodrush** (*Luzula campestris*): the leafy type.

Height.—4 to 10 in.

Flowering.—April to June. On soils poor and dry.

Habitat.—Very common in upland pastures and uncultivated ground.

Habit of Growth.—The shoots come up at a distance singly or in tufts of three, two barren and one fertile. The ground leaves have a short open sheath, and a narrow linear pointed blade like that of a bottom grass, but provided with a fringe of long soft hairs along the whole margin. When the shoot is pulled, the reddish brown base of the sheath becomes visible. The flowering shoot is simple and erect, bears a pair of leaves, and ends in a floral region composed of three or four terminal sessile or stalked ovoid heads of flowers.

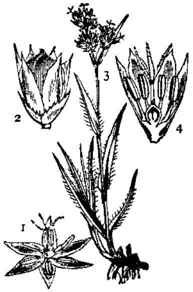


Fig. 24.—Field Woodrush (*Luzula campestris*)

1, Flower; 2, fruit with perianth; 3, rhizome, barren and fertile shoots; 4, flower (L.S.).

Reproduction.—The fruit is formed within the persistent perianth of the flower. It is dry, three-cornered, nearly as broad as long, and chestnut-coloured. For seed dispersal the fruit case opens by three longitudinal valves, and the three seeds within now fall out separately on to the ground for producing the new generation.

Renewal.—Underground there is a stem (rhizome) with rather long creeping branches from which solitary distant green shoots above ground take their origin.

Improvement.—In this case one must consider whether it would be more profitable to plough up the pasture, enrich and cultivate the land, and lay it down anew to grass, or to let things stand as they are.

Natural Order, Labiatæ.

Stems square. Leaves opposite. Flowers two lipped.

Grass Land

44. Vi. P. **Self-heal** (*Prunella vulgaris*).

Height.—4 to 12 in.

Flowering.—July to September. On all soils; most abundant on poor moist land.

Habitat.—In grassy places chiefly, pastures, hedge banks, open places in woods, heaths, grass and clover leys, &c.

Habit of Growth.—The plant is deep green, thinly clad with hairs, and frequently tinged with purple. The stems prostrate and rooting at the base bear stalked ovate and nearly entire leaves. The branches are spreading, often with the internodes quite short. The flowers, arranged in whorls of six, are compacted at the termination of the stem into a dense cylindrical spike with two green leaves seated at its very base.

Reproduction.—At bearing the fruit is found within the two-lipped purple calyx. Here the fruit is dry and hard, constructed of four one-seeded nutlets, which are shed one by one from between the lips of the calyx. Each nutlet serves for producing a new plant.

Renewal.—The stems are renewed from a short underground branched creeping stem (rhizome).

Description of Nutlet.—The nutlet frequently occurs in commercial clover seed. It is ovate, 1½ to 2 mm. long by 1 mm. broad; the surface is smooth, glossy, and brown, with lighter bands. The narrow base bears a minute white heart-shaped appendage. When put into water this nutlet is easily recognized; the light bands swell up into clear mucilage, very prominent on the brown shell of the nutlet.

Eradication.—Plough up, clean thoroughly, enrich the land, and re-seed.

Natural Order, Leguminosæ.

Grass Land

45. Ro. P. **Creeping Rest-harrow** (*Ononis arvensis*).

Height.—1 to 2 ft.

Flowering.—June to September. An indicator of barren sand.

Habitat.—Frequent in pastures and on banks.

Habit of Growth.—This is a rigid, fetid, and clammy plant with viscid hairs, often bearing thorns. The stems grow prostrate and rooting

along the ground, forming as they go numerous widely diverging branches. The lower leaves are petiolate and trifoliate, with oblong finely toothed leaflets $\frac{1}{4}$ to $\frac{3}{4}$ in. long; the leaves on the ascending parts of the stem are simple and reduced to a single leaflet.

The flowers, sessile and large, are produced singly from the axils of upper leaves.

Reproduction.—The legume fruit is found at maturity filling the persistent calyx; it is oblong, $\frac{1}{3}$ in. long, and sometimes three-seeded. To scatter the seed two longitudinal valves open, and the seeds are sown separately on the ground to produce new plants.

Renewal.—Underground a very long stem (rhizome) is developed and constantly extended by the production of underground branches. From this rhizome new shoots above ground are produced.

Eradication.—In this case the only plan is to plough up, thoroughly clean, enrich the land, then seed with a suitable mixture.

Fig. 25.—Creeping Rest-harrow (*Ononis arvensis*)

1, Fruit in calyx; 2, shoot in flower, 3, flower; 4, gynæcium.

Natural Order, Papaveraceæ.

Juice milky. Leaves alternate, without stipules.

Arable Land

46. Sc. A. **Scarlet Poppy** (*Papaver Rhœas*).

Height.—1 to 2 ft.

Flowering.—May to July. On all soils; less on heavy land.

Habitat.—Common in cornfields and arable land.

Habit of Growth.—This is a plant with spreading hairs and white milky juice. From a long tap-root the erect leafy stem grows up and forms branches. All the leaves are sessile, with a long midrib in a deeply lobed blade. The flowers, 3 to 4 in. across, are borne singly on long terminal peduncles with outspread hair.

Reproduction.—At maturity the globose capsule fruit, $\frac{1}{2}$ in. long, is found standing erect and naked on its peduncle. For seed dispersal eight or twelve tiny valves detach close below the broad summit of the fruit case, leaving a corresponding number of pores through which the numerous small seeds come peppering out from the capsules swaying in the wind. Thus the small seeds are sown on the ground for the production of a new brood of Poppies.

Eradication.—

1. Destroy the young plants by spring cultivation or by using the hoe in the root crop.

2. A differential spray which kills the Poppies and injures the corn very little may be tried, namely, a 3-per-cent solution of sulphate of copper or a 15-per-cent solution of sulphate of iron.

47. R. A. **Long Smooth-headed Poppy** (*Papaver dubium*).

Height.—1 to 2 ft.

Flowering.—May to July. On light calcareous soils.

Habitat.—As for Scarlet Poppy.

Distinction.—Very like the preceding, but the hairs of the peduncle are adpressed, not spreading, and the capsule fruit is oblong, not globose.

Eradication.—As for Scarlet Poppy.

NATURAL ORDER, POLYGONACEÆ.

Leaves alternate, with tubular stipules.

ARABLE LAND

48. Gr. A. **Black Bindweed** (*Polygonum convolvulus*).

Height.—1 to 4 ft.

Flowering.—August to September. On all soils; often abundant on light sandy land.

Habitat.—Common in cornfields, root crops, waste ground, &c.

Habit of Growth.—From the tap-root the slender angular leafy stem grows up and twines counter-clockwise round a corn-stalk in its immediate neighbourhood to a height of 2 or 3 ft. If no suitable support is found the stem grows prostrate, seldom extending to a distance of more than 1 ft. The leaves resemble those of small Bindweed, but are readily distinguished by the presence of short tubular stipules originating from the base of the petiole at its junction with the stem. The flowers have short recurved stalks, and are grouped in clusters of three or four; these clusters are loosely arranged along an axis to form the terminal or axillary racemes.

Reproduction.—When bearing, the dull green perianth encloses a one-seeded nut. For dispersal nut and perianth fall to the ground to produce the new plant.

Description of Nut.—This nut is frequently found in grain. It is three-faced like Buckwheat, 3 mm. long by 2½ mm. broad, dull black, and granular on the surface. The nut of Buckwheat is large, 6 mm. long, and dark brown.

Eradication.—

1. Sow pure grain to prevent introduction of the weed.

2. Use the seed-catching box attached to the reaper or binder to prevent seeds shaken off from reaching the land.

3. Autumn cultivation will encourage germination and allow destruction of seedlings.

4. Spring cultivation will tend in the same direction.

5. Hoeing the root crop will get rid of young plants.

49. Ro. A. **Redshank** (*Polygonum Persicaria*).

Height.—1 to 2 ft.

Flowering.—July to October. On all damp soils; tends to shun lime (calcifuge).

Habitat.—Very common in arable land, temporary leys of grass, on ditch banks, damp places, &c.

Habit of Growth.—The plant is glabrous. From the tap-root the erect stem, often red, grows up, and forms remote branches. The leaves are shortly stalked, almost sessile and lanceolate, often with a central dark blotch; the tubular stipule of the leaf fits tightly on the stem and has a hair fringe round its mouth. The flowers are compacted into dense spikes about 1 in. long, some of which are axillary, while others terminate the stem and its branches.

Fig. 26.—Redshank (*Polygonum Persicaria*)

1, Flower; 2, plant in flower; 3, gynæcium.

Reproduction.—Within the perianth a slightly projecting nut is formed. After the nuts have matured and dispersed the whole plant dies—it is an annual.

Description of the Nut. — This nut is a common impurity in commercial clover seed. It is two-faced, plano-convex, round, 2½ by 2½ mm., with a point projecting from the apical end; the surface is glossy and black.

Eradication.—

1. Prevent introduction to the land by sowing pure seed.

2. Hoe and hand pull to prevent seeding.

3. When the weed is growing in grass and clover, spray with a 4-per-cent solution of sulphate of copper at the rate of 100 gall. per acre.

Grass Land

50. P. **Curled Dock** (*Rumex crispus*).

Height.—2 to 4 ft.

Flowering.—June to August. On all soils.

Habitat.—Very common in arable land, temporary leys of grass and clover, pastures, on roadsides and waste land, &c.

Habit of Growth.—This slender Dock is dull green and glabrous, frequently tinged purplish brown in autumn. From the ground one or two tufts of leaves emerge, each leaf with a semi-cylindrical petiole 5 to 9 in. long and an acute-lanceolate blade of the same length, much curled along the margin. The leafy stems grow up erect from the centre of the leaf tuft and bear fairly erect branches. The small flowers have slender pedicels and are arranged in close whorls along the naked summits of the stem and upper branches with the pedicels bent down. Other specialized branches bear nothing but flower whorls from top to bottom.

Reproduction.—The fruit is not naked, but enclosed within three inner leaves of the perianth now enlarged to $\frac{1}{8}$ in. and coloured, without teeth along their margins. At least one of these perianth leaves becomes thick along the midrib and so bears a "tubercle". Within this perianth is the dry one-seeded fruit or nut. At maturity the upper part of the pedicel is detached and shed, carrying with it the buoyant perianth and the enclosed nut. Thus adequate provision is made for reproducing from one Dock plant a numerous and widely dispersed brood.

Renewal.—Underground there is a perennating apparatus composed of a long fleshy tap-root with a short fleshy stout vertical stem (rhizome) forming its summit and its crown. From this crown the new tuft of leaves grows up; if the crown has branched into two, then two leaf tufts appear.

Propagation.—Though a spud has removed the crown, the tap-root left behind forms on its own account adventitious buds which renew the Dock plant. Even slices of the root can propagate and renew the weed. (Compare Dandelion.)

Description of Seed.—The naked nut of this Dock is often found in commercial grass and clover seeds. It is three-faced, pointed at both ends, $2\frac{1}{2}$ mm. long by $1\frac{1}{2}$ mm. broad, with a smooth reddish brown surface.

Eradication.—

1. Sow pure seed to prevent introduction of the weed.
2. Prevent seed formation by cutting early.
3. Remove as much of the fleshy tap-root as possible by the docking iron; spud regularly when signs of renewal appear.

51. R. P. **Sheep's Sorrel** (*Rumex acetosella*).

Height.—3 to 15 in.

Flowering.—May to July. A calcifuge, shunning chalk and the heavier clays.

Habitat.—Very common in temporary leys of grass and clover, dry pastures, cultivated land, waste ground, roadsides, and moors. Wherever the soil is very light and deficient in lime, there the weed abounds.

Habit of Growth.—The plant is slender, dull green, often tinged with

red in autumn, and bears petiolate leaves with an acid taste. All the leaf-blades are narrow and linear, some at least are shaped like an arrow-head with two outspread and pointed basal lobes. The stems are numerous, erect, and simple up to the terminal floral region, where special leafless erect branches grow out for flower-bearing. The stalked flowers are in whorls along the leafless summit of the stem and along the whole of the special branches standing alongside. Thus the slender terminal panicle is produced. On one plant the panicle bears whorls of four to eight flowers—this is the male. On another plant the flowers are much more numerous — this is the female. Sheep's Sorrel, accordingly, separates the sexes and is a diœcious plant.

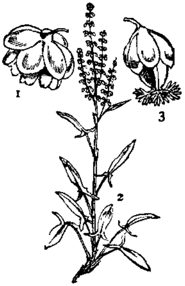


Fig. 27.—Sheep's Sorrel (*Rumex acetosella*)

1, Flower of male plant; 2, rhizome branch with flowering shoot, 3, young fruit from female plant.

Reproduction.—When the female plant is bearing, the upper half of the nut fruit is seen girt at its base by the persistent perianth of the flower. For dispersal the fruit stalks disarticulate and are shaken off, carrying perianths and achenes with them; thus the weed strews on the ground sufficient seed-containing material to produce a brood of many plants.

Renewal.—Underground there is a shallow slender creeping stem (rhizome) extended by numerous creeping branches. From this rhizome the leaves and numerous stems are annually renewed.

Description of Nut.—This nut is a common impurity in commercial grass and clover seeds. It is three-faced, pointed at both ends, 1½ mm. long by 1 mm. broad, with a smooth glossy reddish brown surface.

Eradication.—

1. Do not introduce the weed by using impure seed.
2. Liming is very efficacious.
3. Plough up, clean thoroughly, and reseed.

Grass Land

52. Gr. P. **Common Sorrel** (*Rumex acetosa*).

Height.—1 to 2 ft.

Flowering.—May to September. Prefers rich land (nitrophile) and tends to shun lime (calcifuge).

Habitat.—Very common in pastures, meadows, and open places in woods.

Habit of Growth.—A tuft of glabrous shoots with most of the leaves

at the ground grows up erect and unbranched. The stalked leaf-blades are acid, somewhat succulent, oblong, with the auricles at the base, pointed and directed downward rather than divergent as in Sheep's Sorrel; the upper leaves are sessile and clasp the stem. The whorls of stalked flowers are packed together along the naked summit of the stem, as well as on short leafless and erect lateral branches from the uppermost leaf axils. On one plant the flower whorls are closely packed—this is the male; on another the whorls are fewer and looser—this is the female.

Reproduction.—The female plant, when bearing, produces nuts enclosed within the three inner enlarged segments of the perianth. For dispersal the fruit stalks disarticulate, and the buoyant perianths carrying the nuts within are scattered widely on the ground to produce a new generation.

Renewal.—Underground there is a scarcely creeping stem (rhizome) with tapering roots, from which the new shoots grow up.

Eradication.—

1. Dressings of lime and early cutting exhaust the plant and prevent its spread by seed.
2. Use the spud to get rid of individual plants.

Natural Order, Primulaceæ.

Leaves at the ground form a rosette.

Grass Land

53. Y. P. **Cowslip** (*Primula veris*).

Height.—4 to 12 in.

Flowering.—May to June. On all soils; sandy and calcareous preferred.

Habitat.—Common on pastures, downs, and hedgebanks.

Habit of Growth.—A tufted rosette of wrinkled leaves is formed at the ground. From the axils of some of these leaves simple slender scapes terminating in a number of flowers grow up.

Reproduction.—At maturity the short ovoid capsule fruit is found within the persistent calyx. For dispersing the numerous small seeds within, five teeth open out at the summit, and through the opening thus formed the seeds are gradually discharged and on the ground produce a new brood.

Renewal.—Underground there is a thick stem (rhizome) clothed with fleshy scales, representing the persistent bases of former generations of ground leaves. From the summit of this rhizome new rosettes and new flowering scapes take their rise.

Eradication.—Manuring, close grazing, and regular cutting tend to reduce the Cowslip.

NATURAL ORDER, RANUNCULACEÆ.

Acrid plants. Leaves at the ground or alternate on the stem without stipules, but often sheathing.

ARABLE LAND

54. Y. A. **Corn Buttercup** (*Ranunculus arvensis*).

Height.—6 to 18 in.

Flowering.—May to July. On all soils; heavy land preferred.

Habitat.—Lowland cornfields; not extending to Scotland.

Habit of Growth.—This plant is nearly glabrous, with fibrous roots and a solitary erect leafy stem slightly branched above. Each flower, ½ in. across, is borne on a cylindrical peduncle opposite to a leaf.

Reproduction.—The fruit is naked and composed of a ring of five to seven large flat achenes with hooked spines on the surface. Each achene contains one seed and can produce a new plant. After fruit formation the whole plant dies.

Eradication.—

1. Sow cereal seed free from this impurity.
2. Thorough spring cultivation and subsequent hoeing are necessary.

ARABLE AND GRASS LAND

55. Y. P. **Creeping Buttercup** (*Ranunculus repens*).

Height.—6 to 12 in.

Flowering.—May to August. On all damp and wet soils; not on peat.

Habitat.—Very common in grass land and arable land, on hedgebanks, river-sides, &c.

Habit of Growth.—This is a hairy plant, with special runners for propagation. From a short oblique underground stem (rhizome) with numerous long fibrous roots a tuft of ground leaves is developed.

The individual leaf has a long petiole and a somewhat shorter blade with three divided leaflets and three corresponding ribs; the middle rib is the longest of the three; accordingly the middle leaflet projects considerably beyond the other two, i.e. the leaf-blade is longer than broad. The flowering stems grow out of the leaf tuft, not erect, but decumbent at the base and then ascending. The flowers, about 1 in. across, are borne on furrowed terminal peduncles.

Reproduction.—At maturity the fruit makes its appearance as a naked globular head of numerous one-seeded achenes terminating the peduncle. For dispersal these achenes are shaken off separately and fall to the ground, each to produce a new plant.

Propagation.—For this purpose special stems (runners) from the leaf tuft grow out elongated and slender along the ground. The runner has leaf-bearing nodes widely apart, from which roots grow down into the ground; ultimately the slender connection with the parent dies away, and also the connections between the leafy and rooted nodes of the runner. Each leafy node has now become an independent Buttercup plant.

Description of the Achene.—This achene occurs as an impurity in commercial Ryegrass seed. It is brown, much compressed, 2 mm. long, with a curved beak 1 mm. long.

Eradication.—

1. When this weed is abundant and in grass land, the best plan is to plough up, clean thoroughly, and reseed.

2. To clean the arable land thorough cultivation is necessary. Collect and burn the loosened plants. Two root crops may be necessary to get rid of the pest.

Grass Land

56. Y. P. **Upright Buttercup** (*Ranunculus acris*).

Height.—1 to 3 ft.

Flowering.—June to August. On all soils; light and calcareous preferred.

Habitat.—Very common in grass land and in temporary leys of grass and clover.

Habit of Growth.—This is a hairy erect plant without runners. A tuft of ground leaves grows out from a short oblique underground stem (rhizome) with fibrous roots. The leaf from the tuft has a long petiole and a three-ribbed blade with its parts cut and lobed; the three ribs are of equal length; accordingly the blade is as broad as long.

From the tuft the leafy cylindrical stem grows up erect and bears branches on the upper part. At the terminations of the stems and branches cymose groups of flowers are developed. The flower, about 1 in. across, is borne on a slender cylindrical peduncle without rib or furrow.

Reproduction.—At maturity the fruit is found terminating the peduncle, naked, globular, and composed of numerous one-seeded pieces, the achenes, which readily fall separately to the ground when the stalks are swaying in the wind. Each of the achenes can produce a plant.

Renewal.—When the other parts of the plant have died down the short underground stem (rhizome) remains capable of producing a new leafy tuft and a new stem.

Description of the Achene.—This achene is a common impurity in commercial Ryegrass seed. It is compressed, egg-shaped, 3 mm. long by 2 mm. broad, with an apical beak ½ mm. long; the surface is dull and dark brown.

Properties.—Buttercups are acrid plants, rarely browsed. In hay the

dried Buttercup plants seem to do no harm. On poultry runs Buttercups should not be allowed to form seed.

Eradication.—Plough up, clean thoroughly, take a root crop or two, then re-seed.

57. Y. P. **Bulbous Buttercup** (*Ranunculus bulbosus*).

Height.—6 in. to 2 ft.

Flowering.—May to September. On dry light and calcareous soils.

Habitat.—Common in meadows, pastures, and downs.

Habit of Growth.—The plant is clothed with adpressed hairs. A tuft of stalked leaves grows out from the underground stem. This ground leaf has the petiole much longer than the three-ribbed blade with three divided leaflets. The middle rib is longest; accordingly the blade is longer than broad. From the leaf tuft one, two, or three leafy erect stems grow up and form a few branches, each of which bears a terminal flower. This flower, $\frac{1}{2}$ to 1 in. across, has a furrowed peduncle, and the calyx is reflexed on the peduncle.

Reproduction.—Like other Buttercups by achenes.

Renewal.—Underground there is a stem (rhizome) specially enlarged, as broad as long, like the corm of a crocus, with fibrous roots at its base. From the terminal buds on the upper part of this corm the ground leaves grow out, and then the one, two, or three leafy stems. For forming the new corm a special basal bud is developed. Bulbous Buttercup has no bulb for propagation; for this the solid corm rhizome—often mistaken for a true bulb—is used.

Eradication.—See other *Buttercups*.

NATURAL ORDER, ROSACEÆ.

Leaves stipulate.

ARABLE AND GRASS LAND

58. Y. P. **Silver Weed** (*Potentilla anserina*).

Height.—3 to 12 in.

Flowering.—June to August. On all soils with surface moisture, more especially on places overflowed in winter.

Habitat.—A roadside weed now very common on arable and pasture-land, also on waste ground.

Habit of Growth.—This plant is covered with silvery hairs. From a slender sweet and succulent underground stem (rhizome) with fibrous roots a tuft of ground leaves is developed. Each leaf bears a pair of ovate membranous stipules on the petiole base; the blade has a single long midrib, bearing a large terminal leaflet and about ten pairs of lateral leaflets, a large pair alternating with a small pair. The leaflet is deeply serrate, silky, and silvery beneath.

Propagation.—From the axils of the ground leaves slender simple stems (runners) shoot out horizontally on the ground all around. The tip of each strikes roots, forms a leaf tuft, and ends in a solitary pedunculate flower. From the axil of one of these leaves another slender stem shoots out, appearing as a direct continuation of its slender forerunner. The new tip again strikes root, produces its leaf tuft and terminal flower, and so on. Thus is developed "the long simple runner, rooted at the nodes, bearing four or more isolated tufts of leaves each with a solitary flower". When the slender stem connections between the leaf tufts die away a number of independent pieces are left in the ground, the number of plants corresponding to the number of leaf tufts.

Fig. 28.—Silver Weed (*Potentilla anserina*)

1, Rhizome, rosette, and runner; 2, flower (petals fallen).

Reproduction.—When bearing, the fruit is found seated on a dry knob in the centre of the persistent "double" calyx. For easy dispersal this single fruit is made up of numerous small and distinct one-seeded pieces (achenes) which cover the central knob. These achenes detach separately, and each one on the ground can produce a seedling Silver Weed.

Eradication.—

1. Do not contaminate the land or the dung with roadside scrapings containing runners or achenes of the weed.
2. To prevent propagation the runners must be given no rest on the arable land.
3. Take two root crops in succession to afford opportunity for continued cultivating and hoeing.
4. If the pasture is overrun, plough up, clean thoroughly, and re-seed.

NATURAL ORDER, RUBIACEÆ.

Stems square, leaves apparently in whorls.

ARABLE LAND

59. W. A. **Cleavers** (*Galium Aparine*).

Height.—1 to 5 ft.

Flowering.—June to September. On all soils.

Habitat.—Very common in hedges, cornfields, especially wheat, leys of grass and clover, &c.

Habit of Growth.—From a tap-root the stem grows out and branches freely, especially at the base. The branch stems are square and slender,

and so deficient in skeleton that of themselves they cannot maintain the erect position, but grow prostrate and trailing along the ground. Along the four angular lines of the stem four rows of deflexed prickles or hooks are developed. The lanceolate leaves, ½ to 2 in. long, are arranged in whorls of six or eight; these, like the stem, bear deflexed hooks along their margins. But when Cleavers finds in its neighbourhood any external support, such as a hedge or a cornstalk, the prostrate habit ceases and the stems by means of their hooks climb up the support towards the light.

Fig. 29.—Cleavers (*Galium Aparine*)

1, Flower; 2, shoot in flower and fruit; 3, gynæcium; 4, two-lobed fruit; 5, fruit (L.S.); 6, marginal reflexed hooks.

For flower-bearing special short branches are produced in the axils of an opposite pair of leaves selected from a whorl. This branch consists of a short peduncle, a whorl of green leaves, and three small stalked flowers at the summit.

Reproduction.—A fruiting branch bears three dry fruits, each fruit two-lobed, two-chambered, and two-seeded. To secure dispersal the fruit surface is clothed with hooks which catch in the coats of passing animals and are carried away. Ultimately one fruit splits longitudinally into two closed one-seeded pieces (mericarps), which on reaching the ground choose their own time and season for producing each its own seedling. After fruiting, the plant dies—it is an annual.

Description of the Mericarp.—This mericarp frequently occurs as an impurity in wheat grains, flax seed, &c. It is grey or purple, kidney-shaped, of roundish outline, 3½ mm. long by 2½ mm. broad. When cut across the contents are grey and horny, not white.

Eradication.—

1. Keep the hedges and field borders well trimmed to prevent the introduction of this weed.

2. Use surface cultivation and the hoe to destroy the seedlings and prevent spread by seed formation.

60. Li. A. **Field Madder** (*Sherardia arvensis*).

Height.—4 to 12 in.

Flowering.—April to October. On all soils; light and calcareous preferred.

Habitat.—Common in cultivated land, cornfields, temporary leys of grass and clover, &c.

Habit of Growth.—The plant is darkish green and almost glabrous. From the tap-root numerous square slender branching stems grow out and spread along the ground in a circle with a radius of 3 to 6 in. The

leaves, less than 1 in. long are in whorls of four on the lower part, in sixes on the upper part, and in eights forming the involucres round the terminal heads of flowers. The individual leaves are obovate with narrow base; the upper leaves are narrow and lanceolate with rough margins. The individual flowers of the terminal heads are only $\frac{1}{8}$ in. across.

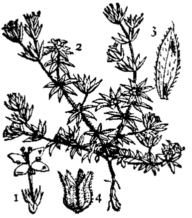


Fig. 30.—Field Madder (*Sherardia arvensis*)
1, Flower; 2, plant in flower; 3, leaf; 4, fruit with calyx.

Reproduction.—At maturity the fruit formed from the inferior ovary is dry, two-lobed, two-chambered, and two-seeded, with a crown of erect acute teeth representing the enlarged persistent calyx. For dispersal the fruit splits longitudinally into two closed single-seeded pieces (mericarps), each crowned with its three teeth. These mericarps are shed separately, and each can produce a new plant. After this dispersal the whole plant dies—it is an annual.

Description of the Mericarp.—This mericarp is a common impurity in commercial clover seed. It is egg-shaped, 2 to 3 mm. long by $1\frac{1}{2}$ mm. broad; the surface is brown or grey, with many white dots representing small adpressed hairs; the broad end bears three projecting teeth.

Eradication.—

1. Sow pure seed.
2. Prevent seeding by free use of the hoe and by surface cultivation from early spring onwards.

Grass Land

61. Y. P. Lady's Bedstraw (*Galium verum*).

Height.—6 to 12 in.

Flowering.—June to September. On dry, sandy, loamy, and calcareous soils.

Habitat.—Common in pastures, downs, and on hedgebanks.

Habit of Growth.—The plant is deep green, with loose tufts of ascending stems which are slender, quadrangular, and hard. The leaves are very narrow and linear, with revolute margins and short white downy hairs beneath.

The flowers, very numerous and small, $\frac{1}{8}$ in. across, are grouped as dense oblong panicles involving leaf whorls. These panicles terminate the stem and the ascending axillary branches.

Reproduction.—At maturity numerous small smooth black fruits make their appearance, two-lobed, two-chambered, and two-seeded. For dispersal the fruit lobes, no larger than a Poppy seed, split apart, and fall separately to the ground. From each mericarp a new plant is produced.

Renewal.—Underground there is a slender woody stem (rhizome), which becomes extended by branching; from this rhizome the air shoots are renewed.

Eradication.—

1. Cut down the air shoots to prevent seeding and to partially exhaust the rhizome.

2. Manurial treatment to favour better herbage is advisable.

NATURAL ORDER, SCROPHULARIACEÆ.

Partial root parasites type.

62. Y. A. **Yellow Rattle** (*Rhinanthus Crista-galli*).

Height.—2 to 18 in.
Flowering.—May to August. On damp soil.
Habitat.—Very common in meadows and marshy grass land.

Habit of Growth.—Underground the tap-root forms fibrous branches, some of which in the soil exploit water and mineral salts, others inserted into the living roots of neighbouring grasses extract therefrom ready-made foodstuffs. The union between the roots of the parasite and the roots of the grass is so intimate that without breakage they cannot be pulled apart. The connection is not superficial, for microscopic examination shows that from the point of contact special ingrowths extending into the central phloem tissues of the grass roots have been formed by the Rattle. Plants with this special mode of life are described as *partial root parasites* because part of the food supply is manufactured after the normal green plant fashion, while another part of the food is extracted directly from the roots of the host.

Fig. 31.—Yellow Rattle (*Rhinanthus Crista-galli*)
1, Open corolla; 2, gynæcium; 3, fruit with calyx.

Habit of Growth above Ground.—The plant is usually glabrous, with an erect square stem and sessile green leaves in distant pairs. The

leaf-blade is lanceolate, 1 to 2 in. long, and deeply serrated along the margin. The large yellow flowers are seated singly in the axils of upper leaves forming a loose terminal leafy spike.

Reproduction.—The fruit is found within a vertically flattened roundish calyx, over ½ in. across, with a narrow mouth surrounded by four teeth. The dry fruit like the enclosing calyx is compressed and rounded; within the fruit there are two chambers and two flat winged seeds per chamber. For seed dispersal two longitudinal valves split away from the capsule; then the seeds are shaken out and, borne by the wind to a distance, settle down on new territory, where another brood is reproduced to further exploit the soil and prey upon the grasses in the new neighbourhood.

Eradication.—

1. Prevent reproduction and spread by cutting the hay early.
2. Early grazing by sheep is said to reduce the parasite.
3. A dressing of 7 cwt. of basic slag per acre, applied before the end of November, has been recommended.
4. A dressing of salt applied in the end of April at the rate of 6 cwt. per acre has also given good results.

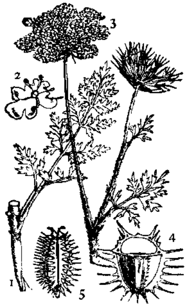


Fig. 32.—Wild Carrot (*Daucus carota*)

1, Tap-root, shoot base, and ground leaf; 2, flower; 3, inflorescence; 4, mericarp (transversely cut); 5, fruit.

NATURAL ORDER, UMBELLIFERÆ.

Leaves alternate on the stem with sheathing bases; blades much segmented.

GRASS LAND

63. W. B. **Wild Carrot** (*Daucus carota*).

Height.—1 to 2 ft.

Flowering.—June to August. On all soils; dry, light, and calcareous preferred.

Habitat.—Very common in pastures, along field borders, and on dry banks.

Habit of Growth.—This plant is light green and rough with hairs. During the first year a whitish hard spindle-shaped tap-root with a tuft of ground leaves and a central bud is developed. As in the cultivated carrot these ground leaves are dissected into numerous pointed segments.

During the second year the solitary erect stem is developed from the central bud. This stem is rough, solid, and branched above. The flowers, small and numerous, are grouped into compound umbels, girt at the base with many conspicuous and segmented involucral bracts. These umbels are borne on peduncles which terminate the stem and its branches.

Reproduction.—At bearing, the whole compound umbel closes up, becoming round externally and concave internally like a bird's nest, containing the small dry oval fruits, $\frac{1}{8}$ in. long, affixed to their stalks within the concavity. This fruit is dry, two-lobed, two-chambered, and two-seeded. For dispersal the lobes split off and become separated, but remain closed, each piece retaining its own seed. From these detached one-seeded portions or mericarps the plant is reproduced. For dispersal by animal agency the surface of each mericarp bears five rows of bristles and four intermediate outstanding rows of spines more or less hooked at the point, which readily catch into the coats of passing animals; thus the mericarps become distributed far and wide. After fruit-bearing in the second year the whole plant dies.

Eradication.—

1. Prevent spread by regular cutting.
2. Prevent the introduction of the weed into the pasture by regular cutting of the field borders.

NATURAL ORDER, URTICACEÆ.

Leaves stipulate and opposite.

ARABLE AND GRASS LAND

64. Gr. P. **Common Nettle** (*Urtica dioica*).

Height.—2 to 3 ft.

Flowering.—June to September. On all soils; those rich in nitrogenous compounds preferred by this nitrophilous plant.

Habitat.—Very common in field borders, hedgerows, patches in grass land, in ruined buildings, and sheltered places on mountain-sides where the sheep and cattle lie, &c.

Habit of Growth.—This plant is clothed with hairs, many of which are stinging. The square stems grow out of the ground prostrate and rooting for a short distance, then they become erect. They bear opposite leaves arranged in decussate pairs with narrow persistent stipules. The individual leaf has a petiole, shorter than the breadth of the blade; the blade itself is ovate with a cordate base and a deeply serrated margin. For flower-bearing special slender branched stems or axes, 1 to 3 in. long, grow out in pairs from the leaf axils; these are clothed with small compact groups of flowers and are called the compound catkins. On one plant the catkins are spread out and ascending—this is the male; on another—the female plant—the catkins are recurved and descending. Accordingly this Nettle, with the sexes separated, is called diœcious.

Reproduction.—The female plant alone bears fruit—a one-seeded achene firmly enclosed within the enlarged inner pair of perianth segments. From these enclosed achenes the seedling nettles are produced.

Renewal.—Underground there is an extended somewhat stout and fleshy creeping stem (rhizome), constantly being added to and extended by the formation of fleshy branches. From this rhizome the air shoots are renewed.

Eradication.—

1. Mow down the shoots early and late to exhaust the rhizome.

2. Dig up the rhizomes as completely as possible and remove; do not neglect to mow down any young shoots as soon as they spring up from the parts of the rhizome left in the ground.

FRUITS AND VEGETABLES

By DUDLEY V HOWELLS, Agric.Dip.(U.C.W.), F.R.H.S.

Fruit Growing

The fruits grown out of doors in the British Isles may be grouped into two classes—hard and soft fruits, or, as they are sometimes termed, top and bottom fruits. In the first group are included apples, pears, plums, and cherries; and in the second gooseberries, currants, both red and black, raspberries, and strawberries.

Planting arrangements vary considerably in different districts, and even on the same holding there may be separate sections planted in totally different methods of arrangement. The hard or top fruit is often intercropped with the soft or bottom fruit.

Many plantations consist solely of apples, pears, or plums, others of one or more of these with gooseberries, currants, or raspberries below, while the extreme of cropping is reached when we have strawberries at the ground-level with gooseberries a little above, and apples, pears, or plums above these.

Gooseberries and black currants are often planted by themselves. More satisfactory crops of top or bottom fruit are obtained when these are grown by themselves, but where the rent of the land is high and labour relatively plentiful it is often much more profitable to intercrop up to the limit. The strawberries more than pay the rent and costs up to such time as the gooseberries come into bearing, while the latter are profitable from the fifth to the fourteenth year or even longer, and by this time the top fruit should be in full bearing. Undoubtedly the strawberries influence the growth and development of the gooseberries and top fruit, but not to the same extent as would grass.

The question whether or not the orchard should contain more than the one type of fruit is a problem for individual determination. The ideal arrangement is probably where top fruit is intercropped with goose-

berries, currants, or raspberries, and where the top fruit in its turn includes both varieties which grow to a large size and come to maturity relatively late and those, termed " fillers ", which come into bearing much earlier. Much can be done in this connection by suitable choice of stocks.

Soils.

Fruit may be grown on a wide range of soils. For most kinds there is an ideal soil, but if the crops were only to be found on these there would be very little grown, while on the other hand it is unwise to think that any piece of land in any district will be suitable for fruit growing. There are very few parcels of land on which fruit could not be made to grow, but the profitable growing of the crop is another matter. Fruit growing for market is a highly technical industry, and careful consideration is necessary before embarking on planting in districts where fruit growing has not been tried.

The ideal soil for most fruits is a sandy loam. Pears do best on a soil inclining to the heavy side, while stone fruit succeeds best on soil overlying limestone.

The nature of the subsoil is often as important as the soil. A very heavy clay subsoil will not suit apples, pears, or plums, and likewise a very sandy bottom makes the maintenance of fertility and the retention of moisture a very difficult problem. Where there is 18 in. of soil on the Old Red Sandstone, or of a good rententive loam, any of the crops will succeed so far as soil is concerned.

Improvement of Soils for Fruit.

One of the first considerations is drainage. It is essential that the young orchard be free from stagnant water, and that the water table be at least 2 ft. down. Many people imagine that a piece of land on a slope must of necessity be dry, but this is not always the case. Tile drains are the most satisfactory. Where stones are plentiful they might be used to form stone or rubble drains as these last for about fifteen years, after which time the orchard will require a great quantity of moisture and thus there may be little surplus to run off.

Where situation and climate are favourable, but the soil unsuitable in some respects, much can be done in the previous cropping to improve matters.

Light sands and heavy clays are both improved greatly by the addition of organic matter, such as heavy applications of farmyard manure or the growing and ploughing-in of vetches, rape, or mustard. A heavy soil will benefit considerably from a dressing of lime or chalk. This is a much more effective method of lightening a clay soil than by applying ashes, sand, &c. If the soil be sour, lime in the form of slaked lime, ground lime, or limestone should be obtained.

Peat soils should be sweetened by the addition of lime or basic slag, and do not usually make suitable orchard soils unless there is plenty of mineral matter present. These soils often produce very good root development, but when the trees are permanently planted they frequently fail to become securely anchored. Such land is better for nursery work than for fruit growing proper. The black currant, however, generally does well on mild peat soils.

Situation, aspect, and climate are all very important. Where the rainfall is very low, apples, pears, and plums will not succeed, as these require a rainfall of at least 30 in. The situation may be either too high or too low-lying for successful fruit growing, the best being one lying between 150 and 550 ft. above sea-level. Gooseberries will succeed in much higher districts than will apples, pears, and plums, and the range in this case is much wider.

A sheltered situation is always best for top fruit, and this is more noticeable in the higher regions than elsewhere. Various plants are used to form hedgerows around fruit plantations. Where the shelter can be put at some distance away from the plantation, elm, beech, or Lombardy poplar may be used, with an inside row of Douglas fir. When only a hedge screen can be allowed, Thuja or beech makes very good protection. A mixed thorn and beech hedge usually affords sufficient shelter for the lower-growing fruits. It is occasionally necessary to plant some fruit-trees themselves to shelter the rest of the orchard, and quick-growing varieties of pears or damsons are sometimes used for this purpose.

There is always a great danger from frost in the lower-lying land, and this is more disastrous to pears and plums than to other fruits. Dry frost does very little injury, but frost in damp, low-lying districts is bad. In most districts a slope towards the south-east will be the best, but this is by no means always the case as the nature of the soil may remove the apparent benefit.

Apples

Soil.

Apples do best in a good sound loam. On very heavy clay soils and in cold districts with high rainfall, apples are liable to suffer from canker (*Nectria galligena*). Where the subsoil is very clayey water cannot percolate readily through it, and the water-logged condition reacts on the tree and produces ill health, and the plant becomes an easy victim to the fungus.

Some varieties of apples do much better on lighter soils, while others are partial to good strong loams. The soil chosen should be easy to work, and thus a reasonable proportion of sand in its composition is an advantage. Gravelly or stony soils are not suitable if these materials

occur to such an extent as to impede cultivation. In districts where the winter is very cold and wet, light land is best.

For apples it is necessary to have plenty of humus, and the soil, where deficient in this, cannot be expected to establish a productive orchard. The land should be improved in this respect previous to the planting of the crop.

Propagation.

The apple is rarely grown from seed or cuttings as on its own roots it takes too long to mature, and the result is usually disappointing.

Two methods of propagation are used, grafting and budding, but most trees are now budded. The tree consists of two parts, the root or stock and the remainder which has developed from the inserted bud or from the ingrafted scion. Much depends on the choice of stock.

Types of Trees.

The apple is grown in a number of different shapes, but for commercial purposes there are only four types worth considering, and these are:

1. Standard.
2. Half-standard.
3. Bush.
4. Cordon.

In shape the standard, half-standard, and bush differ only so far as height is concerned. The standard has usually a main stem about 6 ft. long before the first branch occurs. The main stem in the half-standard is about 3 ft. 6 in. long, while the bush is much nearer the ground but should have 18 in. of clear stem. Certain other differences can be drawn between the types, especially in choice of stocks and pruning.

The cordon is simply a single-stemmed tree from which short laterals arise. Cordons may be planted in an upright or in an oblique fashion, and are set very closely together, about 2 ft. only being left between them. (For further discussion see " Training and Pruning ", p. 233.)

Stocks.

These were formerly divided, according to the popular idea, into paradise, crab, and free stocks. The paradise stock was considered to be a dwarfing stock with fibrous and surface roots suitable only for bush or trained trees. The free stock was thought to be obtained from the seed of cultivated varieties of apples and to be much deeper rooting and stronger than the paradise, and was suggested for standards and as being specially suitable for the weak-growing varieties. The crab stock, raised from seed or suckers from the wild crab, was held to be very hardy and

suitable for orchard trees. While it was deeper rooting than the paradise, it was said to be less vigorous than the free stock.

Investigations at East Malling and at Bristol show that these old ideas were erroneous. Paradise stocks in commerce were found to consist of eight or nine well-defined types which showed great divergence of habit and character. Some were particularly dwarfing, while others were capable of producing a tree as vigorous as any free stock. Dwarfing stocks, moreover, were sometimes found to be of very coarse rootage.

At East Malling vegetatively propagated stocks have been standardized to give four good types which serve all purposes from the single-stemmed cordon to the orchard standard. At Bristol it was found that little or no difference existed between the crab and the free stock, and that stocks raised from the seed of the same variety varied considerably and at most produced only 60 per cent of strong-growing stocks. It is thus more advisable to classify stocks as dwarfing and non-dwarfing. The dwarfing stocks are, with certain exceptions, most suitable for the cordon and the bush, while the non-dwarfing should be used for all but the most vigorous varieties grown as standards, and for those varieties grown as bush which produce too much fruit and too little wood growth when worked on dwarfing stocks.

To a great extent the type of stock will determine the distance of planting, length of life of the trees, and the age at which the orchard will reach maturity.

Choice of Varieties.

The intending grower will do well to make inquiries in the neighbourhood to find which variety or varieties do best. There are a few varieties which are satisfactory throughout Great Britain, both as good strong growers and as market varieties. In most cases a nursery catalogue will not give much help, nor will varieties which do well in walled gardens be necessarily suitable.

For commercial purposes the choice should be from among the following:

Cooking.

- Bramley's Seedling.
- Early Victoria.
- Golden Spire.
- Grenadier.
- Lady Henniker.
- Lane's Prince Albert.
- Lord Derby.
- Lord Grosvenor.
- Newton Wonder.
- Norfolk Beauty.
- Rev. W. Wilks.

Bramley's Seedling, Early Victoria, Grenadier, and Lane's Prince Albert are almost certain to do well, and at least a quarter of the culinary apples planted should be of these varieties.

Dessert.

- Allington Pippin.
- Beauty of Bath.
- Blenheim Orange.
- Cox's Orange Pippin.
- Guelph.
- James Grieve.
- Lord Burghley.
- Mr. Gladstone.
- Rival.
- Worcester Pearmain.

Of these Blenheim Orange usually takes a very long time to come into full bearing, and Cox's Orange Pippin is very subject to canker in the colder and wetter districts.

Arrangement of Varieties for Pollination.

All apples are not self-fertile, and many varieties which are grown commercially are self-sterile, so the planting of an extensive brake of one variety alone is not wise. It is better to plant the orchard with two rows of the same variety alternating with another variety which blooms about the same time and is capable of fertilizing the other.

Early-flowering varieties.

- Beauty of Bath.
- Bismarck.
- Lord Grosvenor.
- Mr. Gladstone.
- Warner's King.

Mid-season.

- Lady Sudeley.
- Lord Derby.
- Newton Wonder.

Late-flowering varieties.

- Cox's Orange Pippin.
- Lane's Prince Albert.
- Worcester Pearmain.

Self-fertile or nearly so.

- Bramley's Seedling.
- Golden Spire.
- James Grieve.
- Lord Derby.
- Rev. W. Wilks.
- Rival.

Self-sterile varieties.

- Beauty of Bath.
- Cox's Orange Pippin.
- Lane's Prince Albert.
- Norfolk Beauty.

Lane's Prince Albert and Worcester Pearmain will fertilize Cox's Orange Pippin. Bismarck is generally considered worth growing for its pollenizing value.

Age of Trees.

The trees should not be more than two years old, but either maidens or two-year-old trees may be used. In the apple two-year-old trees give slightly better results than one-year-old (this is not so with plums), but the former are usually almost double the price.

When the trees arrive they should be unpacked and heeled-in if the

weather is open. If the frost is severe keep them packed and place in a shed slightly above freezing-point until they thaw, and then heel-in as soon as the soil is fit. After unpacking the trees, remove all packing material, as straw will encourage mice, lay them at an angle in a trench, and cover the roots and about one-third of the stem with soil. Fine soil should be filled in about the roots and compressed tightly round them. Severe injury may result if the roots are allowed to dry out before planting.

Preparation of the Soil.

The best plan is to take, the year previous to planting, a crop of second-early potatoes fairly heavily manured. The soil should be well worked, and clean cultivation is essential, all perennial weeds being carefully removed. Much trouble will arise later if the land is polluted with Couch, Coltsfoot, Bishopweed, or Bindweed.

In preparing for apples, bastard trenching or subsoil ploughing will be beneficial, as top fruit differs from bush fruit in this respect.

Planting Points.

The most important points to observe are:

1. Have the soil well and deeply worked.
2. Plant tightly.
3. Do not put rich feeding material beneath the trees.
4. Surface feed and keep a soil mulch.

Apples may be planted at any time during the dormant season, or even after they have commenced growth, provided the soil is in a suitable condition. On heavy soil spring planting is best, but on light soils trees often do much better if planted in the autumn.

Ranging the Field.

This will depend on the distance apart and method of spacing. Bush apples should be given 10 ft. for the compact varieties on dwarfing stocks, 15 ft. for the more spreading varieties, while up to 18 ft. will be necessary for the larger growing varieties. Half-standards and standards will require to be from 20 to 24 ft. apart.

An economical method is to plant either standards, half-standards, or bush apples of the larger-growing varieties at 24 ft. apart, and inter-plant these with bush apples of the smaller-growing, quickly maturing kinds, so that there is a tree every 12 ft. These latter can be cut out when the former require all the room—about twenty years after planting. In the former class would be included such varieties as Blenheim Orange, Bramley's Seedling, Ecklinville Seedling, Lord Derby, Newton Wonder, Warner's King, and Worcester Pearmain. The fillers include Early

Victoria, Golden Spire, James Grieve, Lane's Prince Albert, Lord Suffield, Rev. W. Wilks, and Stirling Castle.

When only top fruit is to be grown and this of a bush shape, the permanent trees can be planted at 18 ft. apart and the fillers put in at 9 ft. distant. There will thus be three times as many fillers as permanent trees, and the fillers should be left unpruned to obtain the maximum crop early.

Two methods of arranging the trees are usually adopted, either the square or the equilateral system. In the latter the trees will form an equilateral triangle with the sides of the chosen distance. Many more trees will be planted to the acre, and the relation between the two methods may be expressed simply thus: for every 10 trees on the square system, 17 trees will be planted on the equilateral plan. Thus, if the trees are to be 18 ft. apart each way, 302 on the square system and 511 on the triangular system will be the numbers per acre required in each case.

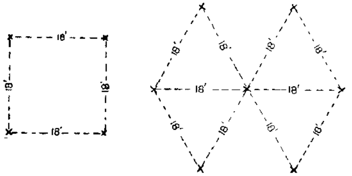


Fig. 1.—Square and Equilateral Systems of arranging Fruit-trees

In ranging the field care should be taken to see that the base lines are straight and at right angles to one another. Determine the line of one row and place sticks along this at the requisite planting distances. From the point where the first tree is to come, measure 24 ft. along this line and put in a peg. With the usual tape-measure put the link over this peg, fix the mark 48 ft. at the tree station, grip the tape at the 30-ft. mark, and draw tight. This will give the right angle, as the sides will be in ratio of 3 : 4 : 5. It is advisable to mark the stations in each line.

Planting the Trees.

Mark off a circle round the stick by attaching a string to the peg and cutting a circular mark with a diameter of about 2 ft. 6 in. A planting board should then be set across what is to be the hole, with the centre (at which point a semicircular cut may be made on one side) just at the upright. Two pegs are driven in at either end and the board removed. After the soil has been taken out to a suitable depth, the planting board is placed again in position across the hole, so as to touch the pegs, and the tree planted with the stem at the centre of the board.

In making the hole care should be taken to see that it is not basin-shaped. Where the tree has to be supported, the stake should be put in before planting and be placed to windward of the tree.

The depth of planting will be governed by the depth to which the tree was planted in the nursery, the soil-level being easily seen. In planting put some of the best soil well in between the roots. When the roots are covered, ram tightly by tramping and fill the hole, after which the soil should be very firmly rammed.

Where it is intended to plant trees in grass—a method which is not always satisfactory but may be necessary where the orchard is to be used as a lambing quarter—the turf should be first removed from the place where the tree is to be planted, and the top spit of soil taken out. Stir the subsoil, put in the turf face downwards, and chop up, afterwards giving a dressing of lime or basic slag and covering with a little of the top spit. Plant in the same manner as previously outlined, and make a note of the variety planted.

Training and Pruning.

As has been stated, the most suitable types are the standards and half-standards, bush trees, and cordons. In all these types it is best to start with the maiden tree, that is one year from the graft or bud. Where, however, two-year-old trees have been planted, the first year's training will have been done in the nursery.

Standards and Half-standards.

In these types the maiden is grown on for one year until it is "feathered". Straight-stemmed plants are selected. In forming the tree the side shoots are left intact during the first year unless they compete with the leader, and the leading shoot is either left untouched or cut back to induce growth so that the head can be formed at a suitable height. In July the lateral shoots should be pinched to six or eight leaves. In the following winter shorten these laterals to three or four good buds, but cut clean out all shoots which occur low down. The side shoots are left on, not to form part of the permanent head, but to aid in producing a strong stem to carry a good head. If they are cut out immediately the stem will be too thin and unable to carry the top.

When the tree has grown somewhat above the required height for forming the head, and when there is a substantial stem, shorten the leader at the winter's pruning, again choosing three or four good buds. Encourage as many buds as possible to push, and in the autumn cut back to about half their length the shoots which arise from these. This will give at least six shoots, which form the main head.

Two types of heads are commonly produced, the open-centre tree and the semi-leader type. In the former the shoot which arises from the bud to which the young tree was shortened, and which grows in an upward direction, would, if left, completely dominate the tree, so it is cut clean out. In the semi-leader type the leading, or central, shoot is

cut back so that it is kept about 6 in. above the height of the laterals, and thus the centre of the tree is not kept open, new main branches arising farther up the tree. See that the branches which form the head are kept at equal distance from each other.

It will be necessary to continue the training for the first four or five years to establish the tree. Too long, whip-like growths will not be suitable, and the branches should be shortened to give stability.

In cutting the shoots it is well to bear in mind that cutting close in to a bud (as in A) gives a top shoot which carries on the direction of growth of the shoot so shortened, while the next bud pushes in an outward or inward direction according to whether the bud is on the outside or inside of the shoot. If, however, the cut be made slightly above the bud, the shoot which arises from that bud will push at an angle with the shortened shoot (as in B.) Thus the branches can be produced inside, outside, or intermediately as desired, by suitable choice of bud and point of cutting.

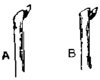


Fig. 2

Bush Trees.

This is a very suitable shape for the slow-growing varieties or for those on the dwarfing stock. They do not require staking and can be planted much closer together than the standards.

A start is made with the maiden, usually the single-stemmed, which is cut back to about 18 in. from the ground-level, so as to leave three or four good prominent buds. In most instances this will result in a similar number of shoots arising in the following growing season, and all that is required is to shorten these back half-way and later remove the leading shoot if necessary. The pruning is best left till April so that the disposition and character of the buds can be seen. The head may also be formed as in the semi-leader type (see standards and half-standards).

Bush trees should have not less than 15 in. of clear stem to facilitate grease banding, which is almost sure to be necessary sooner or later. In order to bring them into fruiting early, the training and pruning of bush trees used as fillers should not be carried beyond the fourth year.

Cordons.

These may be grown in an upright or in an oblique fashion. The latter need support, but a greater length of stem is obtained from an equal height, they carry heavier crops of fruit, and are not so likely to produce strong growth. Except with varieties which are too prolific and which consequently make too little growth, no cutting back is advisable until they reach the desired height.

Pruning.

This operation needs special care and intelligence, and a thorough knowledge of the fruiting habits of the tree is necessary. The reasons generally adduced for pruning are fallacious, and the most common, that pruning induces greater growth, is contrary to experimental results. Harsh pruning is worse than no pruning. Undoubtedly severe winter pruning will produce greater vegetative activity, but the total growth of a pruned tree, compared with an unpruned tree, shows a balance in favour of the latter.

Neither does pruning the actively growing tree induce fruitfulness. When the number of buds on a too active shoot is restricted, excessive growth of those left must result. Severe reduction of the part above the ground results in less carbohydrates being available for the root system, and throws the tree out of balance. When trees are coming into bearing they should be pruned as lightly as possible. A tree which has reached maturity is more likely to need feeding than pruning.

There are three periods in the life of the tree:

1. When growth is taking place and little or no fruit is formed.
2. When growth is not so active and a balance between growth and fruit production has been established.
3. The period of decline, during which there is little growth and when the tree, usually in alternate years, produces heavy crops of fruit.

The object of the pruner should be to so train the tree that it is capable of carrying a crop of fruit, and to restrict excessive growth, where necessary, by keeping the knife or saw away from the tree. A tree which is making no growth may be pruned to induce growth.

Having established the framework of the tree, it is best left unpruned except for the removal of cross branches and those which shut out the light or interfere with picking and spraying operations.

After-care of the Orchard.

This will consist of cultivation, manuring, and spraying for the suppression of insect pests and the prevention and control of fungous diseases.

Undoubtedly an orchard which is cultivated up to twenty years or so will produce much better results than one in which no disturbing of the soil is practised. The worst possible ground cover for the orchard is grass, as plants in sod, especially where the grass is allowed to cover the land during the first eight years, suffer severely. Many of the trees die out, and the difference between those left and trees planted in cultivated land is very marked. Cropping with green crops is not so harmful, and vegetable crops can be grown with little or no effect since the soil must be well cultivated and manured for such.

Where top fruit only is concerned and the land is fertile, no added manure, natural or artificial, should be necessary after the first year until the trees are mature. After this light applications of well-decayed stable manure, at the rate of 10 tons per acre, should be given. Where it is impossible to use stable or farmyard manure artificials may be substituted, and a dressing consisting of the following should be given per acre:

2 cwt. superphosphate.
$\frac{1}{2}$ to $\frac{3}{4}$ cwt. sulphate or muriate of potash.
$\frac{1}{2}$ cwt. sulphate of ammonia.

Little benefit is obtained where the manure is placed close round the trees.

Lime is generally believed to be beneficial to the orchard, and an application of this once in every four years at the rate of $\frac{1}{2}$ to 1 ton per acre should prove sufficient.

Spraying.

This is one of the most essential operations in orchard work and the one most consistently neglected. Sooner or later the orchard will demand attention in this respect, and it is the height of folly to allow an insect pest or fungous disease to obtain a great hold before adopting methods of control.

Preventive measures are at all times preferable to remedial measures, and much trouble may be saved by taking such precautions. Apple orchards have been at times devastated by attacks of caterpillars, when if prevention and remedy had been part of the ordinary routine no such havoc could have resulted.

No definite directions as to time and method of application of the various spray mixtures can be given. Weather conditions play an important part in determining the precise moment for attack. Exact proportions should be used, as haphazard methods sooner or later lead to disaster, and it is absurd to apply, say, a red spider wash at double strength in the vague hope that it will suppress caterpillars.

The trees will usually need clearing of lichen or moss, or both, at some period of their life-history, and one or more insect pest and fungous disease will find there a happy hunting ground. Where a suitable spraying routine is followed, there should be little or no trouble with lichen and moss.

Insect Pests of Apples.

The insects most commonly troublesome in the apple orchard include the Winter Moth, Woolly Aphis, Apple Psylla, Apple Blossom Weevil, Capsid Bug, and various types of Aphides. The spraying and other methods to be adopted will include:

1. Grease banding in September to catch the wingless females of the Winter Moth.

2. Autumn spraying with the following for Apple Psylla:

2 oz. nicotine.
1 gall. petroleum.
7 lb. soft soap.
40 gall. water.

3. Spraying in winter with strong lime-sulphur solution (1 part commercial lime-sulphur to 9 parts of water) to clean the trees and to destroy the eggs of Apple Psylla.

4. Spraying in spring with 2 lb. arsenate of lead to 40 gall. of water, supplemented by 1 gall. of lime-sulphur, or better still by a calcium-caseinate spreader for caterpillars of the Winter Moth and Codlin Moth.

5. Spraying in spring and summer with nicotine, petroleum, and soft soap as (2), for Apple Psylla, Apple Blossom Weevil, Capsid Bug, and Aphides.

6. Where necessary a caustic soda spray may be used in the winter to clean trees which have become neglected, but this should not be used oftener than once in four years.

2 to 2½ lb. caustic soda.
5 pints petroleum.
10 gall. water.

Where Woolly Aphis is prevalent it will usually be found on the roots as well as above the ground, and can only be controlled by injecting a fumigant into the soil, and treating the trees so as to penetrate the wool on the stem.

Diseases of Apples.

Apple Scab, Apple Mildew, Apple Blossom Wilt, and Canker are the most likely to be troublesome. Silver Leaf on apples has now become a serious menace.

Spraying with lime-sulphur, 1 in 10, in winter, followed by summer spraying with Bordeaux mixture, 1 per cent, or with lime-sulphur, 1 in 40 (except for the more tender varieties, such as Cox's Orange Pippin and Lady Sudeley, which should have a 1-in-60 solution), will be necessary as soon as the leaves come out. Where lime-sulphur and arsenate of lead are used as a combined spray, a practice which recent experimental work hardly seems to encourage, the second spraying may be left out.

For canker, cutting-out the wounds and painting with coal-tar or painter's knotting is usually an advantage, and much benefit is also obtained from painting with a cresylic soap (see FUNGOUS DISEASES OF VEGETABLES AND FRUIT, p. 295).

Pears

Soil, &c.

Pears do best on a good stout loam, but many varieties thrive quite well on light soils.

This fruit is much more affected by climatic conditions than by soil. Pears will not do well where the rainfall exceeds 48 in., nor where the winter is both wet and long. In the north they do not thrive unless well sheltered, and the blossom is too early for many districts.

Pears are not grown on such an extensive scale as apples, but where they do well are more profitable. In some districts pears have been planted extensively and the trees only produce rubbish.

Stocks.

Pears are worked on two chief stocks, the crab pear and the quince, but the latter is the more favoured stock as it gives fruit of better quality which matures earlier. With the use of the quince stock the proverb " He who plants pears, plants for his heirs " is not true. Certain varieties, however, will not thrive when grafted directly on the quince, so these are double grafted, a foster stock (scion of another variety) being first grafted.

When pears are grafted on the quince, care must be taken to see that the soil covers the point of union of graft.

Types of Trees.

Standards and half-standards are the most suitable shapes for orchard work.

Planting, &c.

Broadly speaking, methods of planting similar to apples can be adopted.

Pears on the quince should be planted approximately the same distance apart as apples on the dwarfing stocks, while for standard pears 20 to 24 ft. can be allowed. They can thus be planted in a mixed orchard.

Pruning, training, spraying, &c., is similar to apples.

Varieties.

Clapp's Favourite.
Dr. Jules Guyot.
Fertility.
Louise Bonne of Jersey.
Pitmaston Duchess.
Williams' Bon Chrétien.

Plums

In those districts where plums succeed well they are more profitable than apples, but the zone for plums is more limited. The extreme plum level is about 400 ft. above sea-level, and this crop is more likely to suffer from frost in the low-lying districts than is the apple.

Plums need more shelter, but can be grown in districts where the finer dessert apples will not succeed owing to too much moisture.

Soil.

The most suitable soil is a moderate loam overlying a limestone rock or chalk subsoil. In districts where climatic conditions are good, plums thrive on a variety of soils, but very heavy clays and sandy soils are not suitable. The plum is not a deep-rooted plant and is therefore liable to suffer from drought on sandy soils, but on the other hand it will not tolerate stagnant moisture.

The plum does best on a slope to the north-east or north-west, and shelter is very important. Where this is provided naturally by the situation of the surrounding land, nothing more is needed, but otherwise suitable shelter must be planted.

Preparation of the Soil.—Where the soil is acid in character, an application of ground limestone or lime, 1 to 2 tons per acre, or of basic slag, 10 cwt. per acre, should be given.

Trenching is not necessary, and no farmyard manure should be applied at planting time.

Propagation.

Plums are either budded or root grafted.

Types of Trees.

Standard and half-standard plums are most commonly grown. The plum does not do well as a cordon.

Stocks.

The most commonly used stocks are the egg plum, mussel plum, St. Julien, and myrobalan plum. The last-mentioned is said to give greater susceptibility to Silver Leaf. The St. Julien stock is the favourite in Scotland.

Choice of Varieties.

Belle de Louvain.	Gisborne.	Rivers' Early Prolific.
Czar.	Monarch.	Purple Pershore.
	Victoria.	

The most profitable variety of all is Victoria.

Arrangement of Varieties for Pollination.

Czar, Gisborne, Monarch, and Victoria are all self-fertile, while Purple Pershore and Rivers' Early Prolific are partly self-fertile.

Age of Trees.

Plums should always be planted as maidens, as these are infinitely better than either two- or three-year-old trees. If the choice has to be made between two- and three-year-old trees choose the latter.

Planting.

See "Apples" as to methods of planting that can be adopted. Owing to the greatly increased prevalence of a disease produced by *Eutypella prunastri*, which causes plums to die out in their early stages or just as they come into bearing, the whole stem before planting should be treated with a preventive "paint" (see *Eutypella prunastri*, p. 298).

Pruning.

Plums require less pruning than apples or pears, and once the shape is established they should remain untouched.

Where growth is persistently strong the trees should be lifted, the roots moderately shortened, and replanted.

After-care.

Keep weeds in check. If the trees show any signs of "gumming", apply lime or basic slag with a relatively low phosphate content but high in lime.

Spraying.

Plums are subject to attack of Winter Moth, Bud Moth, Plum Sawfly, and various Aphides.

The treatment should include:

1. Grease banding in September for Winter Moth.
2. For Bud Moth, spraying just before the buds open with the following mixture:

   1 gall. lime-sulphur. 2 lb. arsenate of lead. 40 gall. water.

3. For Winter Moth, spraying after the flowers have set, with:

   1 gall. lime-sulphur. 2 lb. arsenate of lead. 40 gall. water.

4. For Plum Sawfly and Aphides, spraying with:

   2 oz. nicotine. 7 lb. soft soap.
   4 pt. petroleum. 40 gall. water.

There are several very troublesome fungous diseases which are widely distributed, namely Silver Leaf, Wither Tip or Brown Rot, and *Eutypella prunastri*.

No satisfactory method of controlling Silver Leaf has yet been discovered. For Wither Tip and Brown Rot see FUNGOUS DISEASES OF VEGETABLES AND FRUIT, p. 300.

Bush Fruit

Soil, &c.

Gooseberries and currants will do well in much more elevated regions than will top fruit, and can thus be grown in zones outside the limits of orchard land.

They do not do in very hot or dry districts, but thrive in partial shade and in moist regions. For this reason they can intercrop top fruit until the orchard becomes too dense to allow light to pass in.

The red currant and gooseberry will thrive on any soil which is not too light, and in which there is a fair amount of organic matter. The black currant prefers a rich heavy loam, but does well in sweetened peat soils. Where black currants and gooseberries are to be planted on the same holding and there is much variation in the heaviness and moisture content in the different sections available, choose the heavier and moister situations for the black currant. In situations where raspberries die out owing to seasonal waterlogged conditions, black currants will often do well.

Situation and Exposure.

Where grown in the warmer and drier districts bush fruit benefits considerably from a northern or north-eastern exposure, but where planted on a south or south-western slope in such districts they are very liable to suffer from drought, and are almost sure to be more liable to attacks of red spider than in the moister, cooler regions.

A lighter soil can be used in the cooler and more moist districts than in the warmer and drier areas, but there must always be a plentiful supply of moisture and the organic content must be maintained at a high level.

Gooseberries and currants do not benefit from the deep working of the soil, and when the soil is decidedly light there is a noticeable disadvantage from trenching.

Propagation.

Gooseberries and currants are grown from hard wood cuttings. In the case of gooseberries and red currants the common nursery practice is to remove all buds but the three top ones before inserting the cuttings, so as to give a bush on a single leg, but this is a decided disadvantage

for commercial growing. The bushes will carry a much greater weight of fruit when they have several stems coming up from below the ground, are not likely to suffer so much damage from the wind, and if attacked by Botrytis the whole bush is not destroyed, the attack usually being limited to one stem.

Cuttings, preferably from young bushes, are taken in the autumn or early in the winter from the young, strong, well-ripened shoots of the previous season's growth. The cuttings, which should be at least 10 in. long, are cut off just below a bud, tied into bundles (care being taken to keep them all one way), and heeled-in in a well-drained situation, covering them with soil so that about half the cutting is beneath the ground-level. These cuttings callus over and even form roots. They should be lifted and planted out before growth commences in spring. Only the strong shoots at least ⅜ in. in diameter should be used, and cuttings taken from leading shoots are not suitable.

Shallow trenches, about 4 in. deep, are taken out and the callused cuttings, cut back to about 8 in. in length, choosing three good buds at the top, are placed along the vertical side of the trench, about 6 in. apart. Not more than three buds should be above the ground-level and the soil should be filled in and pressed tightly round the cuttings. The rows in the nursery bed should not be less than 12 in. apart, as this will allow of hoeing and mulching. A layer of strawy manure should be put between the rows to conserve moisture. When the cuttings are inserted in rich fertile soil and kept mulched they make better growth, and the plants can be used at an earlier age for forming the plantation—a decided advantage. The one-year-old well-grown bush is much more serviceable than the two-year-old one of the same size.

Varieties.

Varieties of Gooseberries.

Lancashire Lad—red. Whinham's Industry—red. Careless—white.
Whitesmith—white. Early Sulphur—yellow.

Careless and Whinham's Industry are the best all-round berries.

Varieties of Black Currants.

Baldwin.
Black Naples.
Boskoop Giant.
Seabrook's Black—liable to reversion, but said to resist "Big Bud".

Varieties of Red Currants

Comet. Raby Castle.
Perfection. Victoria.

Perfection and Victoria are the best of these.

Preparation of the Soil.

The soil for bush fruit should be thoroughly prepared, and when planting for preference this fruit should follow a cultivated crop, as money spent in cleaning the land for gooseberries and currants is a very profitable investment. Foul land should never be planted with bush fruit.

Plough the land deeply in the autumn and cultivate thoroughly before planting. Where a cultivated crop, heavily manured with farmyard manure, has been taken previously there should be little need of applied dung, but where this is not the case it must be given at the rate of about 30 tons per acre, this being ploughed into the land.

Planting.

The distance apart for planting may vary according to circumstances. Where bush fruit is grown by itself, 6 ft. each way is advisable, but where it is planted in orchards the distance apart will be determined by the distance allotted to the top fruit.

When grown with strawberries the distance usually given is 5 ft. 6 in. × 6 ft. This allows of a strawberry bed consisting of four rows 14 in. apart with a pathway of 28 in. 6 ft. each way would be suitable except that the bushes never make the same growth when strawberries are grown in close proximity to them, hence more can be planted to the acre.

In planting, the roots need not be trimmed back; in fact experimental results show that in the case of gooseberries, broken and damaged roots are not a disadvantage.

The land should be marked off in rows, suitably distanced and regularly arranged. After the first line is marked, parallel lines can be drawn with a marker and the plants set alternately along the lines. Holes large enough to accommodate the roots without serious cramping are dug with the spade, and the plants are set tightly and the soil pressed firmly round them. Spring planting is best.

After-care.

For several years it will be possible to intercrop the plantation with various crops, such as potatoes, carrots, parsnips, or cabbage. After intercropping has been discontinued, cultivation should be persisted in to conserve the moisture and kill annual weeds, but near the plants only shallow cultivation can be given, just sufficient to remove the weeds. Turnips, mustard, or rape can be sown thickly to keep weeds smothered out, and be afterwards dug in to serve a useful purpose in supplying bulky organic matter.

Manuring.

Bulky organic manure is best. While top fruit does not appear to respond to applications of dung, except to develop new growth, bush fruit is benefited greatly thereby. It is an advantage if farmyard manure can be applied to the surface of the plantation every year, but where this is not practicable heavy applications should be given previous to planting, and where annual companion crops are grown these may be liberally fed.

Where it is impossible to top-dress with dung, artificials should be given per acre as follows:

I. 8 tons farmyard manure.
2 cwt. steamed bone flour.
2 cwt. muriate of potash.

Or II. 7 cwt. basic slag (in winter).
2 cwt. superphosphate.
2 cwt. steamed bone flour.
1 cwt. muriate of potash.
½ cwt. sulphate of ammonia.

Gooseberries grown in exposed situations often benefit by an application of artificials to induce growth.

2 to 4 cwt. superphosphate.
2 cwt. sulphate of potash.
½ to 1 cwt. sulphate of ammonia.

Pruning.

Red currants bear their fruit chiefly on the old wood or wood at least two years old, gooseberries are both old- and new-wood bearers, while the fruit of the black currant is found principally on the new wood, *i.e.* wood of the previous season's growth.

Pruning Gooseberries.—In garden practice it is customary to cut the leading shoots of gooseberries back to about six buds and the side shoots to three buds, but for commercial work this would be folly. Weight of crop is the point to aim at, and advantage must be taken of the manner in which the fruit is borne.

The first few years are devoted to the production of a good, substantial bush, after which only old worn-out shoots, gross-growing shoots arising from low down on the bush, and the stronger growing leading shoots are touched. The two first-named are cut completely out, while the last are tipped. Thinning to admit light and air will probably be necessary. Not only does a too dense bush produce poor fruit, but picking is rendered difficult and spraying operations cannot be carried out satisfactorily. When the old wood is removed and new wood brought in, the gooseberry bush can be made to grow heavy crops for thirty years at least.

Pruning Red Currants.—In the case of red currants, the new wood should be shortened back about half-way, and many of the laterals will need spurring-in.

Pruning Black Currants.—Black currants should have all old wood cut away to encourage new shoots, and only the too vigorous young growths should be tipped.

Insect Pests and Fungous Diseases.

Bush fruit suffers from a number of insect pests and fungous diseases.

Gooseberries are severely attacked by Winter Moth, Gooseberry Sawfly, Magpie Moth, Aphis, and Red Spider. Among the diseases are American Gooseberry Mildew, Botrytis or Die-back, which attacks red currants as well, and Cluster Cup, which produces red depressed areas on the fruit and leaves. The spraying programme will usually consist of:

1. Dormant spraying with lime-sulphur, 1 in 10. This should be done as late as possible, just as the bush is pushing into growth.

2. Either sodium sulphide and petroleum emulsion, or liver of sulphur and flour paste in the spring for Red Spider.

3. Spraying when the bushes are in leaf, for caterpillars and as a fungicide, with the following:

1 gall. lime-sulphur.
2 lb. arsenate of lead.
40 gall. water.

In the case of black currants the most serious insect trouble is Big Bud. In this the buds are abnormally swollen and do not open out properly. When this is noticed, cut away affected parts and spray the bushes with lime-sulphur, 1 in 12, when the top leaves are the size of a sixpence, usually from the beginning to the middle of April.

The Improvement of Old Orchards

There are many old orchards up and down the country which, if sprayed, pruned, manured, and properly cared for, would produce much heavier yields and better fruit.

The first operation should be the pruning. All dead wood should be cut out, and where the trees have run up too high they should be shortened back, but not more than 6 ft. of branch should be removed in a year. Always cut back to the point at which a lateral branch occurs, and where the limb is more than 2 in. in diameter, coat the cut surface with coal-tar.

When the long bare limbs of a tree are judiciously shortened, growth

will take place from adventitious buds. The shoots so arising may be thinned out, selecting some to form the new fruiting wood. About three years after this pruning the trees should be bearing on this wood. Branches which cross should be cut out, and where one tree runs into another the entanglement should be removed.

Spraying will be the next operation. Where lichen and moss are prevalent give a hot lime wash, using 1 lb. of lime to the gallon of water. Or the following may be substituted:

2½ lb. caustic soda.
4 pt. petroleum.
10 gall. water.

These should be followed by a copper sulphate spray, 1 lb. to 25 gall. of water. If the condition of the trees is not bad, lime-sulphur, 1 in 9, may be used. These sprays remove lichen, moss, rough bark, &c. Other sprays will probably be necessary, specifically directed against various insect pests and fungous diseases.

Whether old orchards should be cultivated or not is a moot point. Where no manure is applied cultivation is certainly beneficial. The best and easiest way seems to be the cutting over of the grass with a scythe or mowing-machine, leaving the grass lying, and manuring the orchard.

Artificials should be given freely all over the orchard, but especially in the area to which the roots extend.

4 to 6 cwt. superphosphate 2 cwt. steamed bone flour 2 to 3 cwt. muriate of potash 2 cwt. sulphate of ammonia	per acre.

Or

4 lb. superphosphate 2 lb. muriate of potash 2 lb. sulphate of ammonia	per tree, 24 ft. apart.

Strawberries

Under most conditions strawberries are a very profitable crop. They demand, however, considerably more attention than most farm crops, and the amount of labour necessary is relatively great. For a period of from about six to sixteen weeks, according to the system of growing, gangs of weeders and pickers are necessary.

Soil.

The soil for strawberries is not such an important factor as is the climate. Strawberries may be grown quite successfully on almost all

soils. Profitable plantations are found on soils in the same district varying from the lightest sand to the heaviest clay. Peat soils are often very productive. For early berries a sandy soil is best, while a heavier soil is more productive and produces better flavoured fruit.

The character of the subsoil is as important as that of the soil. A very light sand overlying a heavier subsoil would be suitable, but a light sand on a sandy subsoil would be valueless unless very heavy dressings of organic matter be incorporated with both soil and subsoil. The organic content is a very important point. A soil where this is plentiful will always retain more moisture, and the ease with which moisture can be moved in the soil is greatly increased thereby.

Stony soils are not unsuitable unless the stones are large. The only objection to finer stones or gravel lies in the interference with the rooting of runners. It is, however, a great mistake to remove the stones from such soils.

Soils which are of a very peaty nature often produce too rank growth owing to the presence of too much nitrogenous material, but this can be modified by the application of fertilizers containing phosphates and potash.

Though the chemical nature of the soil docs not play a dominating part in determining the success of the crop, the soil conditions have a very marked effect. Good drainage is essential, and the water-holding and moving capacities of a soil are very important. In the chemical composition one point needs special mention—excess of lime is very detrimental to the crop.

Strawberries are much more easily worked on a fertile sandy loam than on a heavier soil, but a plantation on a good stiff loam lasts longer without renewing.

Climate, Site, &c.

It is not generally safe to plant strawberries where the winter is very prolonged or where frost is very severe. Where the land freezes deeply there is a great danger of the plants being heaved out and the roots broken. Where snow lies long on the land, and especially where, when thaw sets in, the snow is long in clearing, severe damage to the plants is likely to result.

Situations where the rainfall is high and the air temperature low over a prolonged period are bad. In such situations the plants die out during the spring and the crop only lasts a short time.

The slope of the land is not very important. Strawberries do equally well on land which slopes to the north or to the south. Where the land slopes to the south earliness is secured. This often makes a difference of two to three weeks in the picking, and where a large area is cultivated some early and some late land is very useful in the organization of the

picking. Slopes to the south or south-west are liable to suffer from drought.

Hilly land is much more expensive to work than flat land, and the application of farmyard manure to such land is often a very difficult problem. Where the slope of the land is too great for this operation green cropping may be practised.

Land lying at the foot of a slope is often subject to late frosts and much of the earliest blossom may be destroyed. Flat lands are usually best unless lying too near to a watercourse.

Place in the Rotation.

Strawberries should occupy a place in the rotation. It is a great mistake to grow them too long on the same land. New land will usually stand cropping over a period of from ten to twelve years, with an interval of only two years between the first and second half of this period. It is much better to allow longer periods between two individual crops of strawberries, four to five years being advisable. It often happens, however, that the grower has only a limited area and wants to keep all the land he can under fruit. In this case he can shorten the rotation by bare fallowing until June, then sowing rape, vetches, or mustard, ploughing this in, and taking in the second year an early potato crop followed by rape.

Where strawberry sickness is evident the crop needs very generous manurial treatment, but it is much better to green crop.

Raspberries do quite well on land which has carried several crops of strawberries.

Unless the land be polluted with weeds bare fallows are not advisable, but it is sometimes imperative to adopt this method of cleaning the land.

Strawberries do best when planted after one or more cleaning crops, and it is not advisable to plant straight out of lea. One year out of lea is very desirable strawberry land. The spongy nature of the turf and the presence of various insect pests are both inimical to the success of the young plants, and it is essential to get a good stand of plants. It is sometimes necessary to run the risk of planting lea land, and the preparation of the same is dealt with later.

Strawberries are occasionally grown with companion crops. In the single-row system, during the first year's cropping, potatoes are sometimes grown between the rows. The potatoes are planted first, and when the rows of these are evident the strawberries are planted in rows between. Crops like cabbages, cauliflowers, onions, carrots, &c., are, however, more suitable.

Strawberries are very commonly grown as a bottom crop with gooseberries and apples or plums above. The strawberries have a somewhat

retarding influence on both bushes and trees, but the plantation is rendered profitable until the berries come into bearing.

Drainage.

Too much emphasis cannot be laid on the necessity for efficient drainage. The fact that land is on a slight slope or even on a steep slope does not necessarily imply that the land is naturally well drained. Land on which strawberries are grown should never suffer from stagnant water.

The drains should be laid so that the water table never rises nearer the surface than 2 ft. Where the drains are insufficient to carry off the water at all seasons of the year, serious loss of plants usually occurs, especially in a cold wet spring. As has been previously stated, the strawberry requires large quantities of capillary moisture during the period of active growth and fruiting, and efficient drainage is very important in this connection.

The drains should be laid not less than 2 ft. deep and from 15 to 18 ft. between the minors. The bore should be 2½ to 3 in. in diameter.

Preparation of the Land.

The dominant point in the preparation is the production of a clean planting ground. Strawberries should never be planted on land where perennial weeds are prevalent. The cost of weeding, especially where strawberries are grown on the bed system, is an important item, and this will always be excessive where Couch, Bishopweed, Coltsfoot, Red Shank, and Dandelion are present to any extent. It is much wiser to take an additional cleaning crop. Land which is badly infested with Chickweed needs very careful cleaning.

Where land is foul when planted it will often take as much as the capital value of the land to clean it at the end of the crop. Potatoes are usually taken as a cleaning crop, and tall-growing varieties like Arran Chief are best.

Most strawberries are planted in spring and this allows of autumn ploughing. Except in a very wet winter this is an advantage, but very light land should not be so treated. The autumn ploughing should be deep, 6 to 7 in., and should be followed in the spring by a shallow cross ploughing. Where the land is too steep to allow of autumn ploughing (owing to washing down of the soil) winter or early spring ploughing is given. Strawberries are not usually planted until April, and the ploughing must be done sufficiently early to allow the soil to become well compacted for planting. It is essential that moisture be able to move freely in the soil, and this is impossible in too loose a soil. At the ploughing the farmyard manure should be incorporated.

A firm planting bed is essential, and the soil must be well pulverized

and broken up. Two harrowings at least are necessary, and for this operation the disc harrow is very suitable. The first harrowing should be with the plough furrow, the second crosswise. The number of harrowings will depend on the nature of the soil and on the condition of the land previous to ploughing. The chain harrow will only be necessary when there is any clearing to be done. As a preliminary to planting, the brush harrow is very useful.

Rolling the soil is usually necessary. On a light soil it is essential, and even a heavy soil is greatly benefited thereby. When the land is very heavy, two days should usually intervene between the harrowing and the rolling.

Trenching, Subsoiling, &c.—There does not seem to be much, if any, advantage in subsoiling or trenching. Any apparent benefits are only temporary in character, and permanent results are more easily secured by drainage. Where the soil proper is shallow, extreme care must be taken to ensure that the subsoil is not brought to the surface.

Preparation of Lea Land.—Where circumstances demand that lea land be planted it is essential to get the ploughing done in the autumn. The sod should be first taken off with a skim plough and buried as deeply as possible. A dressing of lime about 1 ton to the acre might with advantage be given some time before ploughing. Soil insecticides are not of much avail for Leather-jackets or White Grubs, and it is usually a waste of money to apply these. The land should be cross-ploughed about 2 or 3 in. deep in the spring and harrowed and rolled frequently to get as firm a bed as possible.

As a preventive against "grub" the American poison bran mash is very useful. Mix ½ lb. of Paris green with 25 lb. of bran. Thin down 2 lb. of treacle with 1½ gall. of water, stir in the bran mixture, and if necessary dry off with bran. Scatter this about the field. About 1½ to 2 lb. of Paris green will be necessary to the acre.

Manuring.

Modern varieties of strawberries need heavy manuring, and the organic content is very important as it exercises a great influence on the texture of the soil. This greatly influences the water-holding capacity.

Strawberries do best in an acid soil and are impatient of lime. Heavy applications of any alkaline manure are bad.

Since the crop has usually to occupy the ground for a minimum of three years—in fact some beds are profitable in their sixth or seventh year—whatever farmyard manure is to be used must be put in before the crop is planted.

In comparison with most farm crops, the strawberry removes very little plant food from the soil, but owing probably to the short time between blossoming and the ripening of the fruit it needs ample supplies in a

readily available condition. This is why soil texture is such an important point. Food in solution must be able to pass quickly in the soil.

Land which has been cropped successively with strawberries over a period needs more generous treatment than land which has never been strawberried before, but on the other hand, where old strawberries are turned-in and the land replanted the following year without alternate cropping or with only a green crop in preparation, there is little need of organic matter. From 30 to 50 tons of well-rotted stable manure to the acre can usually be profitably applied. When the soil is very heavy, peat moss-litter manure is good, but generally straw-litter manure is best. Fresh manure is more detrimental to the strawberry than to most crops owing to the prevalence of weed seeds.

The amount of artificial manure necessary depends on the nature of the soil and on the variety grown, as also on the previous treatment of the land. Some varieties are naturally too gross-growing to stand applications of nitrogenous manures. Certain soft-growing varieties when heavily manured will not travel well, and where this is the case the artificial manure should chiefly consist of phosphates and potash. Farmyard manure is relatively rich in nitrogen, and a well-balanced manuring should rectify this.

As previously mentioned, lime is not advisable for strawberries, and basic slag containing a high lime content is not a suitable source of phosphates. While lime in excess is detrimental to the crop, light applications are sometimes necessary. Where strawberry land is distinctly acid and the ground likely to become infested with Sheep's Sorrel, the lime should be put in with the previous crop; 10 cwt. to 1 ton per acre should be sufficient.

Superphosphate is the most suitable phosphatic manure for strawberries, but bone meal and steamed bone flour are also good.

Of the nitrogenous manures sulphate of ammonia is best, but nitrate of soda is often useful where foliage is deficient and is sometimes used as a top dressing in late spring.

Potash is very necessary, especially in a dry season. With the young plants it is essential to get a good stand of plants, and where potash is deficient on light soils drought has a more marked effect than where potash is given. Potash further gives resistance to eelworm.

The artificial manuring at the time of planting should contain:

15 to 20 per cent soluble phosphate.
5 to 10 per cent insoluble phosphate.
6 to 8 per cent potash.
2 to 2·25 per cent nitrogen.

This may be mixed at home, using:

3 cwt. superphosphate of lime (30 per cent).
1 cwt. steamed bone flour.
1 cwt. sulphate of potash.
¾ cwt. sulphate of ammonia.

It is very often thought that with the heavy applications of farmyard manure artificial manures are not necessary the first year. This is not, however, borne out by experiment. There is a decided benefit derived from the application of artificials. The artificials put on just previous to planting or worked in at the first hoeing supply food in a readily available condition and assist in the establishment of the plants. Where no dung is given, a dressing of the above manure at from 6 to 8 cwt. to the acre should be given.

With varieties which are not naturally of a gross-growing habit, or in seasons where the foliage is backward, the application of a top dressing, just about blossom time, of ½ cwt. nitrate of soda to the acre is very beneficial.

In most cases basic slag is not to be recommended for strawberries. Certainly for the first year or so after application the beds do well, but more quickly pass their best than where superphosphate is used. This applies, of course, only to those conditions where strawberries remain down for three or more years.

Methods of Planting.

There are several methods of growing strawberries.

1. Single-row system.
2. Matted-row system.
3. Hedge system.
4. Bed system.

There are various modifications of these.

Single-row System.—This method allows of horse cultivation. The plants are set in rows 24 to 30 in. apart and from 15 to 18 in. between the plants in the row. Under one system of training, all the runners arising from the original plants are removed. This allows of the whole strength being retained by the plants, which thus develop large crowns. Under the other method two or three runners are allowed to root about 6 in. from each parent plant.

Fig. 3.—Single hedge System

Matted-row System.—In this method the plants are put in about the same distance apart as in the last-mentioned system. The runners are allowed to take root where they can, and there is little or no attempt

to space them or restrict their number until the rows are thinned in the autumn.

Hedge System.—(*a*) Single-hedge system. Here the plants are put out 2 ft. between the rows and 2 ft. in the rows, and two runners are pegged in from each plant later on, all others being removed.

Fig. 4.—Double-hedge System

(*b*) Double-hedge system. In this system four runners are layered from the original plant.

Bed System.—This is commonly used where the after-care of the beds is to be done by hand, and is an excellent method where straw littering is not feasible and where the winter is long and cold.

There are several variations of this system, the most important being the three- or two-row beds. The three-row bed is the more common. In this the rows are 14 to 16 in. apart with a " foot road " after every three rows. The land is divided up into rows 28 to 32 in. apart, and between alternate rows an additional line is planted. 10 to 14 in. is allowed between the plants in the row. Under this system the runners which are thrown out may or may not all be removed. It is, however, a great mistake to get the bed crowded, and with the majority of varieties the rows should be definitely maintained. Runners may be pegged into the lines but not between them.

The choice of method will be determined by a number of different factors. Where most of the labour is to be done by horse-drawn implements the single row has much to commend it. Where land is relatively cheap and labour difficult and expensive to obtain, any other system is well nigh impossible. In districts where the winter is severe and especially on heavy soil, plants are liable to be heaved out of the soil, and this is a more serious matter in the single-row system than in any other. When it is impossible to get sufficient plants to cover the area required under the bed system, the land can be planted temporarily under the single-row system and later converted to the bed system.

Where a plentiful supply of labour is available or where the land is relatively high in price, the single-row system is not usually sufficiently productive, and some other method giving a higher yield to the acre is advisable. The other extreme is reached in the bed system, which is essentially an intensive method of growing strawberries. All the work after the first year is done by hand. The cost of planting and maintaining the crop under this system is high. In the first place, about one and a half times the number of plants are required to set an acre. Where the slope of the land is great the bed system is better than any other,

as there is less possibility of rains washing soil away from the plants and the danger of drought is lessened.

Marking Out the Land.

This is done by an implement usually drawn by hand. The markers are fitted with teeth or run on wheels, and the distance between these varies according to the method of planting adopted. Markers may be of three types:

1. The sled marker consists of three sled runners fixed on a frame at suitable distances apart.

2. The rake type is a gigantic rake set with three teeth on the one side and two on the other. It is sometimes improved by having a hinged joint to allow easy passage over uneven ground.

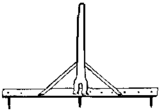


Fig. 5.—Rigid Three-row Marker

3. The roller type consists of a framework running on three small wooden wheels.

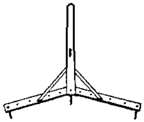


Fig. 6.—Hinged Three-row Marker

In setting out the field a line is stretched along the position of the first row, and either tramped into the soil or pegged at intervals along its stretch. This is essential to prevent its moving when pressed by the marker. The most commonly used form of marker is the three-toothed or wheeled, and is pulled so that the inside tooth or wheel runs along the line. Thus three rows are marked off during the first passage, and on the return journey, or the next crossing of the field, the inside tooth or wheel is pulled along the last row marked. Thus two rows are marked every time the marker is taken across the field.

Marking Out for the Bed System.—When the field has been marked off as previously indicated in rows 28 in. apart, a line is stretched between every other row to form the centre row of a three-row bed. The alternate spaces form the roads between the beds, being thus at the commencement 28 in. wide. As the plants grow and form large crowns the outsiders on the bed encroach on the roads, and the 28 in. becomes reduced to 22 in. or so. This point must be taken into account in laying out the land. If implements set to work a greater width than 22 in. are to be used, the land should be marked off at 30 in. at least. To allow of the passage of barrows, &c., convenient cross roads are made at intervals of about 30 yd.

Where plants are grown on the bed system half as many again will be required to plant a given area as compared with the single-row system. Thus if 15,000 plants were necessary to plant an acre on the single-row

system, 7500 extra plants would be required to convert this into the bed system, or a total of 22,500 per acre.

Propagation.

Strawberries are propagated mainly by means of runners. The mother plant throws out aerial stems which develop clusters of leaves at each node, and these tiller-down with the formation of roots. The number of plants to a single stem may be anything from one to four, and each plant can send out about four stems. Further, if the first-developed plants take root and establish themselves early, these in their turn can form runners. It is, therefore, a simple matter in an early district and during a favourable season to raise from four to twenty runners per plant.

Runners should be obtained only from one-year-old plants. Occasionally beginners put in runners taken from older plants, but this is a waste of time and money. It is equally risky to divide up old crowns to make a plantation. Though the parent plant is capable of producing numerous runners, the number should be restricted to three or four. The plant obtained at the first joint represents the initial effort of the parent and is much stronger than those which follow, just as the first cutting taken from a tuber is better than those which are taken subsequently. This is more particularly noticeable in a variety which has been some time in commerce than in a new seedling variety. The constant propagation of a new production by hand-pegging every possible runner cannot but be harmful in the long run, though it is often practised to increase the stock of a promising kind.

These first runners should be hand-pegged. Hand-pegging may consist of definite layering into turfs placed near the mother plants, or of the placing of flat stones on the stem just behind the first node. The growing point of the stem should be nipped to prevent further production.

The plants are best left in the rows or beds until the land is ready. If it is necessary to remove the rooted runners before this time, they may be lifted and heeled-in in rows to remain until they can be planted.

It is particularly important to observe two points in the heeling-in. The plants should be put in so that the roots have space and the crowns must be left uncovered. Heeling-in does not mean burying. A shallow trench is taken out with a slight slope inwards on the side against which the first lot of plants are to be laid. The plants are spread out along this surface, and the soil is thrown forward just to cover the roots and then rammed firmly. The next row is put in about a spading's distance from the first and so on. Heeling-in should be practised with plants that have been a long time in transit. This enables the plant to regain a natural state of turgidity and is preferable to planting immediately.

When it is desirable to plant in the late summer or early autumn, the plants should be hand-pegged into inverted turfs or into pots placed

along the rows. Pots can hardly be used where there is a considerable area to plant.

Lifting and Preparation of the Plants for Planting.

Where large areas are to be planted, plants should be lifted with a hand fork, trowel, or chisel. Even if it were desirable it is not possible to tackle the planting of large areas with the plants already embedded in a ball of soil. Lifting with a ball of soil is also likely to disturb too much the soil in the rows or beds. In any case shaking the plants clear of soil, trimming them, and inserting by means of a dibber gives much better results.

After the plants are lifted they are gathered into baskets and taken to a shed where they are dressed, put in bundles of twenty-five or fifty, and placed in layers in a half-barrel or suitable container for carrying to the new field. Usually the squad lifts one day and plants the next. The dressing consists of removing all dead and diseased leaves together with the attachment to the parent plant, and the trimming back of the roots. The roots of good strong plants will be usually too big for transplanting and these should be cut back to within $2\frac{1}{2}$ or 3 in. from the base of the plant.

For heavy soil a longer root is necessary than for a light soil. The shortening may be done with a knife or with small hand shears. Rootlets are more quickly developed when the tips of the roots at least are removed.

Planting.

In preparation for the actual planting, the rows should be well tramped to consolidate the soil. A planter working on only one row at a time will cover the ground more quickly than if he attempts two rows. Gener-

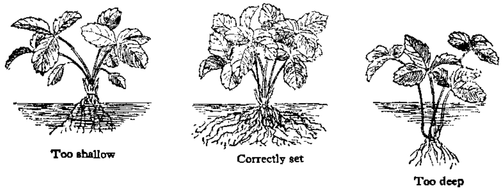


Fig. 7.—Right and Wrong Methods of Planting Strawberries

ally men are the most successful planters. A good worker can plant 3000 to 4000 per day, and women average about 1500 plants. The plants are first placed in the rows at the proper distance apart. The

planters soon learn the exact space required, but it is sometimes advisable to use a wheeled marker. This is so arranged that when passed along the row it leaves a depression where each plant is to be set. Care should be taken that the minimum amount of exposure is given to the plants, as when long exposed to strong sunshine they become useless and the roots dry quickly.

Several different implements are used for making the holes for the plants, viz. trowel, small spade, or dibber, but the most satisfactory is the dibber. The spade is a very slow method, and the trowel can only be successfully used in well-prepared soil. Where the land is heavy the dibber is quickest.

Fig. 8.—Roots of a Runner trimmed back prior to Planting

Care must be taken to use a dibber so shaped that it makes a wide-mouthed hole without going too deeply, and this is arranged by having a swollen leg to it. The operator should straddle the row and push in the dibber to the requisite depth with the right hand, at the same time lifting a plant from the basket with the left. The plant, gripped by the neck between the thumb and forefinger, is given a good shake to straighten the roots, and is then dropped into the dib hole. The roots should be placed in the hole at such a depth that the crown of the plant will be, when set, just on a level with the surface of the soil. The dibber is then driven in vertically with one stroke about an inch in front of the plant in order to fix the roots securely in the soil. A plant will grow just as well firmed with the dibber at the back or side, but by inserting the dibber in front of the plant, with the row directly beneath, confusion of movement is avoided. No part of the operation is more important than the firming of the plant in the soil. Where plants are put in loosely a poor stand is always the result. It should be impossible to pull up the plant when one of the leaves is subjected to a sharp pull.

After-care.

The young plantation must be kept well cultivated. A loose skin of soil should be maintained throughout the summer and all weeds must be kept down. Much of the success of the crop depends on the first year's cultivation, especially where the strawberries are expected to remain down for a number of years. Efficient cultivation ensures that the plants are subjected to a minimum of competition from weeds, and that by conserving the water in the soil the danger of drought is removed.

The implement best suited for cultivation will depend on the system of planting. Where possible the work should be done by a horse-drawn implement as this saves expense: a one-horse implement is the most suitable. Where this cannot be used wheel hoes or Paxton hoes must be relied on. A much greater area can be covered per man by the wheel hoe than by the Paxton hoe. The wheel hoe, set with the " path cleaner ", is very suitable for the road, and the single-wheel hoe is better than the double. The space in the bed must be cultivated by the hand hoe, the most suitable type of which is the Paxton.

The beds should be constantly cultivated to keep a loose soil mulch to the depth of an inch, and this is essential after heavy rains except on heavy soils, where consolidation of the soil will enable the water to dry out more quickly. As soon as the surface is dry in the heavier soils the hoe should be put through. It will usually be necessary to give a hand weeding in the autumn, and if the number of runners is to be restricted the surplus can be removed at this time. All perennial weeds must be dug up.

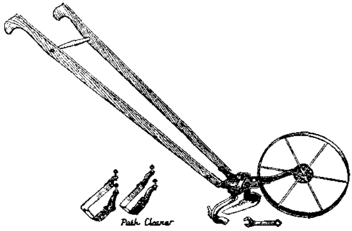


Fig. 9.—Wheel Hoe with Path Cleaner

The first operation in the spring will be the application of artificial manures. These should be put on where possible in February.

As soon as the weather is favourable for planting, all the runners except those which are to be pegged or have pegged themselves in the lines should be removed. This will usually result in the beds containing about three times as many plants as were set, and gives an opportunity to repair any failure of plants.

After the runners have been removed the beds should be weeded. This may be done by a man with a Paxton hoe followed by the weeders, or else by women and boys using strawberry chisels or spuds. A second weeding before picking is usually necessary.

The beds should be weeded before winter comes on. During winter the roads between the beds should be cultivated, this operation being done with the spade or with a mechanical implement like the Simar cultivator. The runners which project into the roads must first be cut off, and with all the weeds removed from the beds at the last weeding can be dug in at this time. In the spring all runners still in the beds should be removed.

Constant working of the soil between the rows, the letting of air into the soil, and the drawing of soil slightly round the plants, tend to maintain the plants in a profitable state for a longer period than where this is omitted.

Mulching.

Where strawberries are grown on the single row or the hill system, and also to a less extent in the bed system, a mulch is often applied either in the autumn or just before blossoming according to the objects to be served. In districts where the winter is very severe or where alternate freezing and thawing are liable, especially on heavy soil, to throw out the plants, the danger of this is removed thereby. In this case the mulch would be applied in the autumn. Soil under a mulch takes longer to freeze and thaw and the danger of severing the roots is thus reduced.

Mulching is not, however, a guard against late spring frosts, for as a general rule the blossoms pushing up through the straw are more subject to frosting, possibly owing to the greater amount of moisture held. A damp frost always causes more damage than a dry one.

Mulching is also useful for retaining moisture and for protecting the fruit from damage during heavy rains; with suitable material it may supply some organic matter and in addition act as a weed control.

The most suitable mulch is obtained by the application of straw or the shaken-out litter from a stable where the horses are well bedded. The latter material should be exposed for a short time before application, as with fresh manure there is always a danger from scorching. Great care must be taken that as few weed seeds as possible are introduced with the mulch.

Where autumn mulching is practised the whole of the ground, plants and all, is covered to a slight depth, but in spring mulching the litter is only bedded round the plants. With the autumn mulch it will be necessary to go over the bed as soon as the danger of severe frost is passed to remove the litter from above the plants.

Picking, Packing, Marketing, &c.

The picking season lasts from about six to ten weeks, according to varieties grown and to the different soils and aspects on the holding. Everything necessary should be in readiness.

Boys and girls or women make the best pickers, and it is wisest to start with them while young, say at ten to fourteen years of age, and endeavour to keep the same workers year after year. Men or women unaccustomed to picking do not usually ever learn to pick properly. Provision must always be made for a foreman or boss to be in command of each squad of not more than twenty-five to thirty pickers, and one or

two youths will be necessary for keeping the workers supplied with baskets and for wheeling away the picked fruit.

Strawberries should never be allowed to become dead ripe before gathering, but where they can be marketed within twenty-four hours after pulling they should be allowed to ripen on the plants. For distant markets they must of course be picked in a relatively unripe condition.

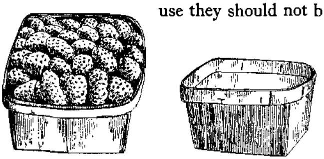
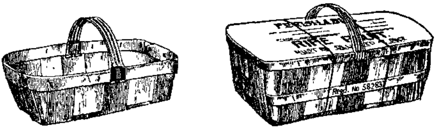


Fig. 10.—Square Punnet

Where the strawberries are intended for table use they should not be husked, but for jam making husked berries are preferred. In the former case the stem should be nipped off about ¼ in. behind the *calyx*, and the fingers should not come into contact with the flesh during the operation. Strawberries bruise much more readily where the stalks are removed.

For dessert the berries should always be put straight into the container they are to be marketed in, the best size being the 4-lb. basket. In picking, the new hands should half fill the baskets, and these should be handed to a skilled worker to finish, as the look of the basket is very important from a selling point of view. During the picking it is quite simple to adopt a system of grading. The basket should contain approximately the same grade of fruit throughout. Where grading on the field is possible it is much better than grading in the packing shed, as the berries are not twice handled.



Chip Basket **Chip Basket with Patent Wood Cover**

Fig. 11

In every field the berries can be divided into large and small, and the latter should be sold in barrels for jam-making or marketed in 4-lb. baskets ready husked for jam-making. Where the grower adopts the rule of marketing only the best berries for dessert he can always command a much higher price for these than if he were to market " throughs ", and the price received for the jam berries does not usually fall much below this, and his costs for picking are slightly less.

In average weather the beds should be picked over every two days, and it is better to pick in the dry than in the wet, but it often happens that during wet weather picking is done for the barrels.

Packages.—These should be either 1-lb., 2-lb., or 4-lb. containers, the most suitable forms being called punnets in the 1-lb. and 2-lb. sizes and chip baskets in the 4-lb. size. The punnets are packed into crates capable of holding 24 punnets. In some districts a crate and chips are used containing 9 chips holding 4 lb. each, the baskets and crates being specially made. This combination forms a very useful package, easy to handle and with very little likelihood of damage.

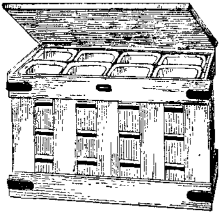


Fig. 12.—Market Crate
To hold 24, 32, or 48 1-lb. punnets

Varieties.

There are a number of excellent varieties of strawberries. Some are much more suitable in certain districts than in others, and care must be paid in the selection as to whether comparative immunity from mildew is essential.

Amazon or Jacunda: good grower and fruiter; very late; very promising variety; too much foliage.
John Ruskin: good cropper; not much foliage; liable to mildew; one of the best commercial varieties, but very susceptible to eelworm.
King George V: good early berry; liable to frost.
Laxtonian: fruit large, firm, dark coloured in some seasons; plants liable to die out.
Lord Overtoun: late; an excellent table strawberry; liable in certain seasons to be unshapely owing to imperfect fertilization.
Scarlet Queen: an old variety; certainly one of the finest strawberries ever produced; only suitable for certain districts.

Three recent introductions of Messrs. Laxton, The Duke, Tit-Bit, and Lord Beatty, promise well. Messrs. Lister, Rothesay, have a very promising seedling.

Strawberry Eelworm (*Aphelenchus fragariæ*).

This eelworm is associated with a disease in strawberries known locally as Red Plant, Red Leaf, and Little Plant, but it has not been definitely established that the eelworm is the sole cause of the trouble. It also produces a curious malformation of the inflorescence, giving rise to the "Cauliflower Strawberry".

There are two more or less distinct types.

1. *Red Plant.*—The plants are moderately well grown, the leaves have a pronounced wrinkling of surface and particularly long petioles. The petiole is usually red, and the leaves may be marbled with red splashes. The margin of the leaf is often red or brown. There are varietal differences in the symptoms.

2. *Little Plant.*—The foliage is very stunted, the plants are dwarfed with an abnormal development of shootlets, and the petioles and leaf margins usually have a decided red tinge. The leaves may be reduced to the midribs.

Infection is carried in the young plants, which generally grow well during the first season, throw a moderate crop of runners, and look quite healthy until April or May. No new roots are formed, and the further development of the plant is prevented. The plants appear to get smaller each day, and the disease seems to travel along the rows. A whole bed or row may show infection at once, or the disease may be seen on isolated plants. The severity of the disease varies with the variety.

A long rotation should be practised, and it is essential to obtain plants from a clean stock.

Raspberries

The soil and climate play a very important part in raspberry growing.

Soil, &c.

Raspberries thrive fairly well on soils ranging from light sand to medium clay, but the cultivation for market must be restricted to those soils which will supply the plant with abundance of moisture and at the same time are not too heavy. The raspberry is a very surface-rooting plant. Its productiveness is directly dependent on the extent of the development of the root, and this in its turn is in inverse ratio to the amount of water contained in the top spit. Soil which is heavy and which does not allow the water to pass freely through is bad, and for the same reason the land must be well drained. Soils which are liable at any time to be flooded or in which the water table rises to within 18 in. of the surface are not suitable.

The best soil is a medium loam tending towards a light clay loam, well drained, and rich in organic matter. It is particularly important to ensure that there be plenty of available moisture in the soil. A light soil may be so handled that a constant supply of moisture is available from it, and many very successful plantations occur on what might be termed sandy loams. When these are improved by the application of sufficient organic matter and when drainage is perfect, the grower can by constant and thorough surface cultivation conserve all the moisture and thus maintain the crop in an active growing condition.

The subsoil is quite as important as the soil proper. The most suitable subsoil is one which tends towards the heavy side, a silt or clay loam being best.

Some peat soils are also useful, but these should have a fair percentage of mineral matter in their make up, and are not of much use when they become hard and caked during any part of the season.

Raspberries do not do well in low-lying situations. The canes are often seriously injured by excessive cold, especially when the cold air is laden with moisture. Where a low-lying area surrounded by land at a higher level is chosen, the downward passage of the cold air in winter causes the tips of the canes to die back and may even completely destroy them.

Aspect is not so important as in many crops. Naturally a south or south-west exposure gives earlier fruit, but in warm districts a north or north-west exposure is much less likely to suffer from drought, and a heavier average crop is secured. Where shelter is available this is very useful. In situations where the prevailing wind is south-west, there is a further benefit in choosing a north-west exposure.

Much depends on the previous cultivation of the land. Land which is at all foul should never be planted down to raspberries. Since the crop has usually to occupy the land from five to ten or even fifteen years, weedy land will during that period become much worse, and be well-nigh impossible to clean after the plants have been removed. Weeds afford cover for many of the insects which prey on the raspberry, and efficient cleaning is for this reason alone worth while. Too much stress cannot be placed upon this point. The raspberry will not stand any deep cultivation near the roots, and therefore if perennial weeds are not all cleaned out before planting they must be left in. The raspberry is even more impatient of disturbance than the strawberry.

Raspberries should never be treated as other than a crop in the rotation. When they have been grown on land for ten years or so it is necessary to resort to farm cropping or else to grow some other fruit crop. Much disappointment often results when the land is too soon again planted with raspberries. It is customary in some districts to plough out the old roots and put in potatoes. The following year the land is put back to raspberries, but this rarely proves successful. A raspberry grower must have enough land to allow of his taking a sufficient number of crops between two crops of raspberries on the same piece of ground. It is advisable to have an interval of six years, but the time can be shortened by catch and green cropping. Green cropping with vetches, rape, or mustard enables the store of organic matter to be brought up to a high level, and the nature of these crops and their smothering effect on weeds, together with the relatively large amount of working necessary, will facilitate in bringing the land into condition quickly.

Where land has become raspberry sick it is sometimes possible to

grow strawberries quite successfully. Black currants, except where the plantation has become infested with the raspberry weevil, do fairly well if the soil is not too light.

The potato is the best crop to precede the raspberry, and where properly worked, and provided sufficient precautions be taken to suppress weeds, will leave the land in good condition. Second early potatoes are most suitable, and care must be taken to see that they are all lifted. In some districts the weather conditions may be depended on to kill out all tubers left in the ground, but this is the exception rather than the rule. A good application of well-decomposed dung should be put in with the potatoes.

Preparation of the Land.

Deep ploughing is essential, but it is necessary to see that the subsoil is not brought up. With all shallow-feeding or surface-rooting crops this is important, and particularly so in the case of the raspberry. 10-in. ploughing is advisable, but where the land will not stand working to this extent some other crop should be taken to assist in the preparation of this depth.

Plenty of organic matter is essential, and this should either be ploughed in during the early autumn or be put in immediately below the plants. The raspberry will usually benefit from autumn planting, and it is therefore advisable to get the work well forward. The soil must be well pulverized and the furrow slice must be cut up. Disc harrows are useful for this purpose, as they assist more in the consolidation of the lower level than does any other implement.

Propagation.

The raspberry may be propagated by seed, cuttings, or suckers (offsets). Seed propagation is usually very unsatisfactory; and only in the case of increasing the stock of new varieties are cuttings used.

Suckers.—Raspberries throw up new canes at the stools and, in addition, at some little distance from the mother plant, other canes are usually thrown up from underground stems. The latter canes can be removed from the plantation with roots attached and be planted. It is essential that the suckers are only taken from young plants. A plantation which has been picked more than three times should never be used as a source of new plants. Undoubtedly canes are often taken from older plants than this, but just as the strawberry grower will only plant from maidens, so the careful raspberry grower always uses canes from young plants. When ordering canes it should be stipulated that they are to be from one- or two-year-old plants. Many lots advertised are from old plantations, and are much inferior, though often much larger in size, than one- or two-year canes.

Manuring.

Raspberries pay for good feeding. As has been mentioned previously, the water supply is an important point, and retention of moisture in an available condition can best be secured by plenty of farmyard manure. 20 tons of well-decayed manure to the acre should be the minimum, and is usually put in below the plants. Where the manure is to be ploughed in over the whole area more will be necessary.

Unlike the strawberry, the raspberry can be easily top dressed with dung, and an application of this is advisable every year, so for this reason nearness to a station is advisable. Very few raspberry farms produce sufficient dung to meet their requirements, and several districts have, owing to the high cost of haulage, proved unsatisfactory for raspberry growing.

The raspberry differs from the strawberry in being partial to lime, and applications of this should be periodically given to the plantation. Every three years ½ to 1 ton to the acre should suffice on any but very acid soils.

In some plantations it is customary to top dress the rows alternate years with manure and lime respectively, while in others the lime is first applied and the manure spread afterwards. In top dressing the rows with dung the soil is drawn back from the stools, and the manure spread right along the rows, which are then moulded up with soil.

Besides dung, raspberries need artificials—phosphates, potash, and nitrogen being necessary. It is essential to secure a good development of young canes, and nitrogen is important for this. A well-balanced manure for raspberries should contain about:

12 per cent soluble phosphates.
6 per cent insoluble phosphates.
2·5 per cent potash.
2·2 per cent nitrogen.

This could be readily made at home from:

8 cwt. superphosphate (30 per cent).
2 cwt. steamed bone flour.
2 cwt. sulphate of ammonia.
1 cwt. sulphate of potash.
7 cwt. sand, gypsum, or other diluent.

4 cwt. to the acre of this mixture should be given. Where no sand, &c., is used apply about 3 cwt.

Time to Plant.

The raspberry many be planted at any time from November to the end of March, but the most suitable time, weather conditions permitting, is November.

When a considerable area has to be planted, or when the weather is unsuitable for the work, it will be necessary to heel-in the plants to prevent their drying out. Neglect of this precaution may spoil the whole plantation.

Planting.

The distance is an important factor and will depend on the methods of cultivation and training.

The three chief systems on which raspberries are grown are:

1. Row system, or espalier-trained on wires. This is certainly the best, but the initial cost for wires, posts, &c., is fairly high.

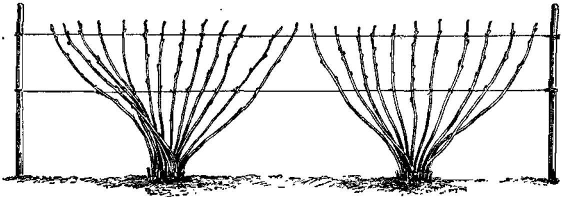


Fig. 13.—Row System

2. Row with stakes. No wires are used in this system, but the canes, often from two or three plants, are bunched up and secured to a stake.

3. Arched system. In this method the stakes are usually put in

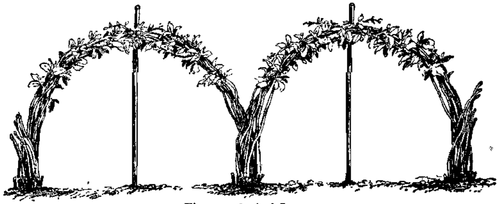


Fig. 14.—Arched System

intermediate between the plants, and half the canes are tied over to the left and half to the right.

The wire system is very much better, as it gives a decidedly greater area for fruiting and presents a much more orderly appearance. The

most satisfactory distance between the rows is from 4 ft. 8 in. to 5 ft., and the stools are planted 21 in. apart.

The land is moulded as for potatoes, the drills being 2 ft. 4 in. apart, the farmyard manure being first placed in the trench. In preparation for planting, the young canes, which are usually packed in bundles of twenty-five, are cut with a hook to about one-third of their length.

The planters walk along the row, the man with the spade in front of the man with the plants. Two plants are placed together in position in the row, the man with the spade fills in the soil all the way round the plants, and the other man consolidates this soil with his feet and at the same time places two more plants at a distance of 21 in. from the last for his partner to cover in. In this way the work proceeds, one man planting and the other holding and consolidating. Plants should be put in somewhat deeper than they originally were. Potatoes may be grown between the rows during the first season.

The only treatment necessary during the first year is artificial manuring. Phosphates and potash ensure the development of an active root area, and the mixture previously mentioned should be applied after the plants have started to grow. Thorough horse cultivation to exterminate the weeds between the rows, and hand hoeing to clean the stretch near the plants, will form the bulk of the work in this year.

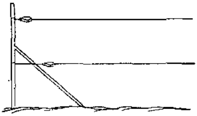


Fig. 15.—Wire Trellis

During the second year the wire trellis should be erected. A stout post with a suitable strut is placed in position at each end, and these must be capable of withstanding considerable strain. It is not advisable to have the pressure exerted behind the post, as this wastes space and is a great nuisance in working.

Intermediates are put in 18 ft. apart and two wires run, one at each side of these, at a height of about 12 to 15 in. from the ground-level. The wire is fixed at one end and the other is attached to a radiseur, which in its turn is secured by a length of wire to the other end post. As the radiseur is wound up the wire is strained tightly between the end posts, and staples are then driven into the intermediates to hold the wire at the correct height above the ground-level. These staples should not be driven right home as they may require to be removed and the wire must also be free to pass through them. The old canes are cut out and the young ones worked in between the wires. A small wire clip may be used at suitable distances to close the two wires, and the canes may then be tied.

Cultivation must be kept up. During the first year the working of the soil will have drawn some away from the canes. A layer of farmyard manure is spread along the row and the soil turned up with the plough

so as to cover the manure. Later a dressing of artificial manure should be applied. In some cases a crop may also be taken during the second year, but this is not always advisable.

After the second year another wire will be put on the trellis 18 in. above the first pair of wires, and in some cases a further wire may be necessary at a later period, but only at the first height of wiring are two wires used at the same level. At this time the number of canes kept at a stool may be reduced to seven. One of the lower side wires is loosened and the canes worked in against its neighbour, after which the wire is once more tightened. The canes are then tied in with an endless string which loops the cane. The distribution of the canes along the framework is so arranged that they receive the maximum amount of sunshine. No. 10 gauge wire is the best to use.

Another method of training worthy of notice is the tying of the cane to posts. This somewhat simplifies the cultivation, as with the canes planted in groups of three at a distance of 2 ft. to 2 ft. 6 in. apart much more use can be made of horse labour and of wheel hoes. In some cases two posts are put to each set of three plants, and the old canes remain tied to one while the young canes are tied in to the other. This protects the young canes and facilitates picking.

The raspberry can ripen very well in showery weather.

Picking and Marketing.

Most of the raspberry crop is barrelled (usually in 1-cwt. barrels) for the jam factory, as this is the easiest method of dealing with the crop and does not require either the careful supervision or the skill necessary for punnet or chip work. The pickers usually pull into enamel-lined pails which are all previously weighed. When they bring the pail to the weighing stand the spring balance indicates the weight in the pail and they are paid at once. Most of the raspberry picking is piecework.

The raspberry does not carry as well as the strawberry, and the punnet is the most suitable package for other purposes. Where chips are used a 3-lb. one should be the maximum size.

Insect Pests.

Raspberry growers have several insect foes, the most important being:

Clay-coloured Weevil.
Red-legged Weevil.
Raspberry Beetle (the so-called "Bug").

Of these the most decidedly troublesome is the Clay-coloured Weevil. This insect in its grub stage gnaws the roots of the plant, and in its adult condition eats little holes in the stems and leaf-stalks, which turn down,

an attacked plantation presenting a white appearance owing to the lower sides of the leaves being turned outwards.

3 lb. arsenate of lead.
½ gall. spreader.
40 gall. water.

If the rows are sprayed in May and again in June with the above mixture this will usually stop serious havoc. Wherever a plantation has been known to be infested, spread cresylic lime or naphthalene and lime.

Varieties.

Antwerp (red): very productive.
Baumforth's Seedling: fruit large and dark; good for punnets.
Lloyd George: tall growing, free cropping, good.
Royal: one of the best varieties.
The Devon: good grower; does not pick easily.
Semper Fidelis (Mitchell): a very good commercial variety; crops well; preserving.
Superlative: in some districts this does exceedingly well.

Celery

Where celery does well it is a particularly paying crop, and is always worth a trial by the grower who is adjacent to market or who supplies direct to his customers. In one district the small holdings, which were at one time almost exclusively devoted to ordinary agricultural crops, were saved from extinction by the rapid development of celery cultivation, and these holdings are now almost entirely used for the growing of celery, carrots, and potatoes.

Celery was formerly grown chiefly in market gardens round London, but most is now produced in the Fen district of Lincolnshire.

Great changes have been made in the market cultivation of this crop, and most of the work is now performed by horse labour. Where the greater part of the work has to be done by hand the grower cannot compete with Fen-grown celery, but his crop has the advantage of being marketed fresh, and with a plant like celery nearness to market is a great advantage. Further, the preparation of the land for celery leaves the soil in a very suitable condition for many other crops.

Soil, Situation, &c.

Celery requires a deep, rich, retentive soil inclining towards the heavy side, especially for the main crop. The situation should be open and well drained. Water must be able to percolate easily through the soil, and this is impossible where the drainage is defective. So great is

the amount of water required—the plant being almost semi-aquatic—that it may be necessary to resort to irrigation to supply its needs in this respect.

Reclaimed peat soils usually make good celery land. For preference the peat should be mild, and it is an advantage if it contains a fair percentage of inorganic matter. Sandy stretches overlying peaty soils situated near the seashore do very well, but such soils must first of all be well drained. This is usually done by cutting open ditches and later on putting in pipe drains. On land which is very spongy this preliminary draining by the open-ditch method is essential to shrink the soil before draining with tiles, as otherwise these tiles may be brought within the region of cultivation.

Generally two or more crops should be taken off the land before the celery is planted. Corn followed by potatoes will be a suitable cropping. Previous to the corn crop the land may be dressed with lime, ground limestone, or basic slag to correct any acidity, and before the celery crop the land may need a further application of basic slag.

Celery is also grown on land where the organic matter is supplied by dung. Profitable early crops of celery are grown on beds which consist almost entirely of well-rotted stable manure.

There are two different methods of planting—on the flat and in trenches. The latter, which is gradually falling into disuse, entails a relatively large amount of spade labour and is not so suitable for commercial work.

Preparation of the Land.

Plough the land deeply in the autumn and later harrow and cultivate very thoroughly. When grown in trenches, these should be prepared early in the season, and peas can be grown very conveniently between the rows, which should run north and south. The peas will afford shade and shelter for the young growing crop, and later the whole of the soil will be available for earthing-up to blanch the celery.

For market work shallow trenches are taken out, and a liberal application of well-decayed stable manure is put in the trench and dug in, being afterwards covered with 3 or 4 in. of top soil in which to place the young plants.

Raising the Plant.

Celery is only half hardy, and the seedlings for all but the late crop must be raised in heat or with some protection.

For the earliest crop, which should be ready for market about the middle of August, the seed must be sown in heat, late in January or early in February. Usually two or three sowings are made in boxes or pans in heat in a greenhouse, or in boxes or on prepared beds above a hot-

bed. Where the earlier sowings are made on a mild hot-bed, night protection must be given and the frames should be covered with mats.

A late sowing, about the end of April, may in the most favourable districts be made in the open. It will usually be necessary to protect the seed-bed at night in those districts where there is the slightest danger of frost. Any check will cause the plants to run to seed, and extraordinary care must be taken to see that the seedlings are not chilled.

The soil for the seed-bed should be rich and retentive, and an application of lime to the compost is usually beneficial. For the first sowing, seed-pans or well-drained boxes should be filled with the compost and firmed thoroughly. The seeds should be scattered thinly over the surface, lightly covered with some very fine sifted soil, and watered thoroughly.

For the later sowings a few inches of rich soil should be spread over a mild hot-bed and well firmed. Very shallow drills should be marked off at about 6 in. apart, and the seed scattered thinly in the drills and covered with a sprinkling of very fine soil. This soil may be conveniently spread by sifting it through a fine sieve on to the bed, which should then be lightly rolled or trampled.

The seed will germinate fairly quickly in the greenhouse or on the hot-bed, but when sown outside it takes about twenty days to come up. The young seedlings must not be exposed to too bright sunshine, and shading may be required. In the frame, ventilation will be necessary soon after the seedlings are through the soil, and should be increased gradually as the weather improves.

Much care is essential to keep the plants growing uninterruptedly and the seed-bed free from weeds, and water should be applied when necessary.

After about three weeks from the time the plants show, they may be given their first transplanting. For the earliest batch cold frames are more commonly used, but for the main and late crops, beds for transplanting should be made in sheltered situations where protection can be easily given in unfavourable weather.

The bed should be formed by treading a patch very firmly and then spreading about 4 or 5 in. of well-rotted stable manure, mixed with leaves, over the surface of the patch and covering this with 2 or 3 in. of fine rich soil. The plants should be pricked off when they have made three leaves.

Some growers build the transplanting bed on an ash pathway, by placing 4 or 5 in. of manure and leaves on this and spreading 2 in. of soil on top. The roots penetrate through the manure to the ashes, and the plants can afterwards be cut out in squares for setting out in their permanent quarters.

The bed to which the late celery sown outdoors is transplanted should be shaded from the hottest sun, and is better open towards the east but

shaded from the south and west. The soil must be retentive of moisture and the site well drained. The plants are pricked out about 3 in. apart each way, and kept well watered until they are ready to go into their permanent quarters.

Planting Out.

Celery is usually grown in single or double rows. Where horse labour only is available the single-row system is the only one possible, but where all the work is done by spade two rows are often grown about 10 in. apart. Where the latter system is adopted the plants in the one row should alternate with those in the other.

Celery grown on the flat is less liable to disease than when planted in trenches, and is more easily cultivated. The plants are put in single- or double-row beds, but the single-row bed lends itself more readily to cultivation. The distance between the beds varies according to the nature of the crop grown between; from 3 ft., where lettuce or cauliflower (or both) is intercropped, to 4 to 6 ft., where peas are used. Short-season peas should be grown and these may be followed in favourable districts by cos lettuce.

Some of the earliest transplanted seedlings will be ready for putting out into the rows or the trenches about the end of May, so at this time the bed should be cut lengthwise down the rows and given a good watering. About two days afterwards a spade is run horizontally under the plants and they are conveyed to their permanent quarters. A line should be stretched along the row, and the holes made at least 6 in. apart with a trowel or a very wide planter. The plant should be pressed in the hole and soil well consolidated round the ball, care being taken to see that the crown is not covered.

After planting, copious supplies of water must be available, and the subsequent cultivation will be concerned with the conserving of the soil moisture. Shading after planting is sometimes necessary. This may be provided by fixing a board upright along one side of the row and resting on it one edge of a wide board, the other edge being on the soil.

Earthing-up to Blanch.

Cultivation and weeding will be necessary during the whole of the growing season; and the soil should be put up round the plants as they increase in height. If the moulding-up be delayed until growth is finished it takes much longer to blanch the sticks. After the last earthing-up it will take about six weeks before the celery is ready for market.

Early celery is sometimes blanched by putting boards close up to the rows, or by tying soft cardboard collars round the sticks. With the late celery the banking or moulding is usually done in two operations. About the middle of September d round the plants half-way up

to ensure a vertical stick, and about a fortnight later the final earthing is given. When celery is planted on the flat, a special moulding plough capable of earthing the adjacent sides of two beds 3 ft. apart is used. The plants are sometimes tied preparatory to moulding.

After the cold weather has set in and the soil has cooled down, the celery may be lifted and stored for the winter in a number of ways, but all successful storage methods must provide for the maintenance of the plants just above freezing-point, sufficient moisture at the roots to keep the plants turgid, and efficient ventilation. A very simple method of storage consists in digging a trench about a foot deep and placing the roots, packed close together, in moist soil. Build a wooden framework round the sides of the trench and cover with boards to form a span roof to keep out the wet. Before severe frost sets in, cover with soil and straw.

Varieties.

Red: Major Clarke's Red.
Manchester Red.
Standard Bearer.
White: White Plume.
Clarke's Early Market White.
Sandringham White.

Onions

Onions are among the most profitable outside vegetable crops, a considerable area being devoted to them in Great Britain, and there is opportunity for extension.

They thrive equally well in warm and in cool districts, provided they can obtain sufficient moisture during the young stage. For properly maturing the bulbs the hotter the weather the better. They can be started comparatively early, and a long cool growing season followed by a period when the temperature reaches a high level is best. The crop, therefore, is most suited to those districts where the range of temperature is greatest. In cold wet autumns there is often some difficulty in ripening off, and this depreciates the keeping qualities of the bulbs.

Onions are marketed in three forms:

1. Young onions sold in bunches for salads and for flavouring.
2. The bulbs developed to a small size and marketed as pickling onions.
3. The bulbs grown to a large size and stored for sale during winter and spring.

In addition there is the production of onion sets and the growing of autumn-sown onions to give between-season supplies.

Soil.

Onions do quite well on soils which vary from a light sand to a moderately heavy loam, provided the texture and drainage are satisfactory and the organic content is high. An open situation is very important.

The soil must be capable of being well consolidated, and it is essential that the moisture can pass quickly up to the plants. There are three great factors in the production of this: thorough and deep cultivation, plenty of organic matter, and the maintenance of a constant soil mulch. Add to these efficient drainage and the absence of weed seeds, and the ideal conditions are obtained. Contrary to the general impression the onion is not a deep-rooted crop, but must have its food material brought to it in solution. Land which is liable to become puddled by working in wet weather, or which becomes baked and cracks in dry weather, is not so suitable.

Onions do best on soil which is exceedingly rich, and it is better to avoid new land straight from lea or land which has been impoverished with ordinary cropping. Where new land has to be taken in for the crop, start two or three years ahead to improve its fertility by taking two previous crops which require or can stand generous treatment. The crop immediately preceding the onions should be specially chosen for cleaning the land. Great expense and much damage are occasioned if the land be full of weed seeds, and it is always better for this reason alone not tc put the crop on new land.

Onions may be grown on the same land for four or five years in succession, or until it is necessary to change on account of the development of fungous diseases or because of attacks of the Onion Fly. "The onion does best on an old onion bed."

Preparation of the Soil.

The land must be worked deeply and plenty of organic matter incorporated with the soil in the autumn, the surface being left rough over the winter. In February a fine tilth should be obtained by constant harrowing and rolling. This will give a fine seed-bed and consolidate the soil.

Manures.

The bulk of the manuring should be with farmyard manure, but much benefit is derived also from artificials.

For inducing growth nothing surpasses nitrate of soda, but excessive use of this causes greater susceptibility to disease and may produce bull-necked bulbs, and it is therefore necessary to use a balanced manure.

A good dressing of basic slag (22 per cent), 4 to 6 cwt. per acre, is usually worth while, and potash in some form or other is essential.

Except on soils which are exceptionally rich in organic matter, a dressing of well-decayed stable or farmyard manure will be needed. Land rich enough to grow other vegetable crops without the addition of such manure will usually pay for added manure for the onion crop. Where onions are grown on land for the first time 30 tons of dung will be none too much, while the same land will need 15 tons per acre each year in preparation for onions, but could easily carry two or three other crops without further feeding.

Much depends on the availability of the plant foods and the texture of the soil, and the previous manuring and cropping will give the best indication as to the necessary ingredients. Analysis of the soil will not give any reliable information except so far as the organic content is concerned.

Before sowing the seed or setting out the plants as the case may be, apply 4 cwt. basic slag and 1 to 1½ cwt. of muriate or sulphate of potash.

1 part steamed bone flour
1 part sulphate of potash
1 part nitrate of soda
} applied at the rate of 2 to 3 cwt. per acre as top dressing,

followed by:

3 parts superphosphate
1 part sulphate of potash
1 part sulphate of ammonia
} applied at the rate of 3 cwt. per acre as top dressing.

Bunch or Spring Onions.

These pass under various names in different districts. The soil should be in very good heart, clean, and of good texture. Never sow spring onions in land which is at all dirty. Sow at the same time as for autumn-sown onions, in drills 12 in. apart, and roll lightly to consolidate the soil.

The rows may be put closer together than 12 in., but sufficient room should be left to allow of working the soil with the wheel hoe and for the workers to pass between the rows. Since a loose surface mulch is necessary, as soon as the onions are up the wheel hoe or the Paxton hoe should be used between the rows.

Nitrate of soda, 1 cwt. to the acre, may be given with advantage early in the spring to rush the crop on.

Spring onions are marketed in bunches of twelve or more.

Variety.—White Lisbon.

Autumn-sown Onions.

As these have to pass the winter in the seedling stage, land recently enriched with dung and artificials is not so suitable as land that has been liberally fed for a previous crop.

Autumn-sown onions may be grown after early or second early potatoes. The land should be well cultivated by ploughing, cross ploughing, and disc harrowing. The seed should be drilled in rows 12 in. apart and the soil well rolled. The time for this autumn sowing varies considerably in different districts, ranging from the last week in July to the first week in September.

The hoe should be put through the bed immediately the rows can be seen and the land thus left clean over the winter. In February transplant to a well-prepared permanent quarter where the plants should be set out in rows 15 in. apart and 6 to 9 in. between the plants in the rows. The seed-bed may be thinned to allow the plants to be a suitable distance apart for growing on where sown, and the surplus can be marketed as young onions.

It is essential to have the transplanting done before the soil becomes dry. The plants should be lifted with a trowel or a hand fork, and the roots nipped back and spread out so that they are not huddled together in the dib hole (see "Transplanted Onions", p. 278).

Autumn-sown onions grow to a larger size than spring-sown onions, are usually ripened off earlier, and are less liable to the attack of the Onion Fly. When the spring is unsuitable they may run to seed, and they do not keep so well as spring-sown onions. The most commonly grown varieties for autumn sowing are White Spanish, Tripoli, and Giant Rocca; Ailsa Craig is sometimes used.

Pickling Onions.

Onions grown for pickling differ from those grown for other purposes in that the bulbs must be small, and premature bulbing and ripening is desirable.

The soil should be poor and dry, and the seed is usually sown thickly, later than the main crop of onions, and left unthinned. Sow in drills 6 in. apart, cover lightly, and keep down weeds (see "Onion Sets", p. 279).

Pickling onions may be grown between the rows of carrots, where the latter are 18 to 24 in. apart, and the onions keep the fly from the carrots.

Variety.—Silver Skinned.

Large or Keeping Onions.

These are grown in three ways:

1. Spring-sown in their permanent quarters and thinned.
2. Spring-sown in heat and transplanted.
3. From onion sets.

Spring-sown Outdoors.

The seed must be sown early so that the plants may be well grown

before the hottest part of the season, and for this reason it is practically impossible to obtain a good yield from spring sowing in the open in Scotland.

The land should be well prepared, and no seed should be sown unless a good tilth has been produced. Plough the manure into the soil in the autumn or winter and leave the land in ridges for the frost to get in. In preparation for the crop, level the land, clear away all debris, and use the harrow and roller to break up the soil to the requisite fineness and sufficiently to consolidate the ground. The land should not be got ready much in advance of sowing the seed, and cultivation in wet weather is often disastrous.

Good seed only should be used and sown at the earliest favourable opportunity, in drills 12 to 15 in. apart, but must not be covered deeply, ½ in. of soil being sufficient. The seed may be sown with a seed barrow or with the single-wheel seed drill, the latter being the handiest for the purpose. A string is drawn tightly along the first line, and the machine, suitably adjusted for depth and with the marker fixed so as to mark the next row, is pushed down the inside of the line, thus sowing, covering, and lightly rolling the seed.

In order to facilitate weeding, mix the onion seed with about one-tenth its weight of radish or rape seed. The radish or rape germinates quickly, and long before the onions come up the hand or wheel hoe can be passed between the rows, thus leaving a comparatively clean bed. The radishes can be marketed without interfering with the onions.

The quantity of onion seed required per acre depends on the method of sowing adopted. Sown with radish 3 to 4 lb. only is necessary, but sown alone an even seeding cannot be obtained with less than 5 lb. Where the young onions or thinnings are to be marketed it is often profitable to use a much larger quantity, up to 10 or 12 lb. per acre.

The greatest expense in the cultivation of onions is that of cleaning and thinning. The latter must be done by hand, and the amount of seed sown will often determine the cost of this operation. Where there is little labour available for thinning it is exceedingly important to obtain good seed, as there is then a direct control of the amount of thinning to be done. Where onions fail to germinate properly there is no use in resowing, as by that time the season will be too far advanced.

As soon as the radishes are through the ground, or as soon as the rows can be seen, the wheel hoe should be passed along to keep down the weeds. The best attachment for this purpose is the 8- or 12-in. path cleaner. The Dutch or the Paxton hoes are not so suitable for this purpose, as there is always a danger of cutting and injuring the bulbs. The most suitable time to work the land is when the soil is just getting dry after rain, and it is imperative to keep a loose skin on the surface. This cultivation is generally carried on until early in August, and in the onion-

growing districts is usually let out on contract. The hoeing will last about three months, and with the wheel hoe and attachment mentioned one man should do from ¾ to 1 ac. per day.

Following the first weeding after the onions are up, they should be thinned for the first time, this operation being performed when the ground is moist. Thinning should not be long delayed and must be done before the seedlings are ½ in. in diameter. If large onions are required allow 6 in. between the plants. Sometimes the onions are half thinned at the beginning, and the remainder removed and sold for picklers after they have formed small bulbs.

Varieties.

Ailsa Craig.
Bedford Champion.
Cranston's Excelsior.
James' Long Keeping.
Rousham Park Hero.

Transplanted Onions.

This entails more handwork than either of the other two methods, but where large onions are wanted, is the most satisfactory of all. Except in very mild situations it is necessary to raise the seedlings in heat, for which a mild hot-bed may be used. In this method there is a great saving of seed, the cost of thinning is obviated, and a much heavier yield is obtained.

The seed is sown on a specially prepared seed-bed, either in seed-pans or, for commercial work, more commonly in a frame, and the soil must be rich and free from weeds. Sow in rows about 3 in. asunder, and cover the seed with about ¼ in. of soil. About 3 lb. of seed are required per acre if the plants, when transplated, are to be set out 3 in. apart, but the usual distance is 6 in.

Keep the temperature of the frame moderately low while the onions are growing, and see that plenty of ventilation is given. The onions should be transplanted as soon as they are the thickness of a lead pencil.

The plants must be put early into their permanent quarters, while the soil is moist, and will not do well if they are not planted by the end of April in England or the middle of May in Scotland.

The rows are marked off with the wheel hoe and marker, or with a drag-marker in which the teeth are set at the required distance apart (see "Strawberries", p. 246). The marker should cover at least four rows at a time. A revolving disc, as is sometimes used for distancing forest seedlings, arranged so as to mark off every 6 in., will be of great assistance in spacing the plants in the rows.

The holes may be made perpendicularly, either with a dibber or a trowel, though the former is much more speedy than the latter, but when used the roots of the onion plants should be shortened considerably

so as to bring the root ends in contact with the sides of the holes, and to prevent entanglement of the roots. New rootlets are only thrown out where the tips come into contact with the soil, but deep planting is not good. After the roots of the plant are inserted in the hole the soil must be rammed firmly. Removal of the lower leaves will facilitate hoeing afterwards.

Onions from Onion Sets.

Of late years large quantities of onions have been grown from sets. These sets are small onions of the previous year which were arrested in their growth and forced to form small bulbs.

Onions grown from sets suffer much less from attack by the Onion Fly than when spring-sown, but they have the disadvantage of being much more liable to run to seed. By using sets, planting can often be undertaken much earlier than seed could be sown, and there is a greater surety of securing mature bulbs in unfavourable weather; but against this must be set the higher cost of producing the crop.

The sets are obtainable in quantity, but there is not as a rule any specific variety guarantee. Where desired, sets may be grown at home as mentioned below. The sets should not be more than ¾ in. in diameter, those about the size of the thumb-nail being suitable. If the sets are too large the plants run to seed, while if they are too small they have not sufficient available food to give them a good start.

The land should be treated exactly as for spring-sown onions, but the sets themselves should be hand planted. At least 12 in. should be allowed between the rows, and the sets inserted about 4 to 6 in. apart in the rows. In planting, care should be taken to see that the little bulbs are put in right side up, and to arrange that while the set is not quite covered it is yet pressed down to bring the base in contact with a moist layer of the soil, and is firmly planted. The other operations and manuring are the same as for spring-sown onions.

Producing the Sets.

Two methods are followed in the producing of onion sets. The first consists of sowing the seed fairly thickly, late in the season, on a poor dry piece of ground. The hot weather, poor ground, and thick seeding cause premature ripening, and this keeps the bulbs small. About 35 to 40 lb. of seed are used per acre.

The second method is to sow seed very thickly, using anything from 70 to 90 lb. per acre, on good onion soil, and to leave the plants unthinned. When the tops start to shrivel the plants are gathered, the tops twisted off, and the bulbs collected in baskets. The bulbs are afterwards spread out in the sun to dry, and subsequently stored in a light airy shed until quite dry. As small a quantity of soil as possible should be left on the

bulbs. They are later put through sieves, first over a ¾-in. mesh and later over a ½-in. mesh, only the bulbs retained by the latter sieve being used for sets, the others being sold for picklers.

Ripening-off and Harvesting the Onion Crop.

Whichever method of growing is adopted, care must be taken to keep a loose skin of soil on the surface, and the only other necessity is to see that the onions ripen off properly.

When the season has advanced sufficiently the tops should be turned down. In twisting the necks it is better to turn two rows towards one another to allow a path between every two rows. As a further aid to ripening, the bulbs may be given a half turn to break some of the roots and so restrict the feeding. The same result may be obtained by passing the onion harvester attachment to the wheel hoe along the line.

Where the necks have not been turned down, harvesting operations will start as soon as the plants have fallen over and the tops have turned yellow. The onions are lifted and may be left exposed to the sun for a few days, or even weeks, turning them often, or they may be dried in an airy shed or under glass. As soon as the onions have dried somewhat they should be topped and stored in crates.

"The modern method of harvesting onions . . . dispenses with field-curing, and completes the pulling and topping in one operation. The onions remain bright in color, there is no loss due to injury by excessive heat or moisture, and no expense in repeated handling. The onions are pulled at the stage already indicated, before the tops are dry. When a handful of onions is pulled, the tops are grasped in the other hand and twisted off. The onions are dropped into a crate, or into a basket to be tipped into crates. . . . The crates are 4 ft. long, 3 ft. wide, and 4 in. deep, the bottoms are made of lath with ½-in. cracks for ventilation, the ends are 5-in. boards, and the sides 4-in. strips. The crates are filled level with the sides, so that when stacked one above the other there is at least 1 in. between the onions in one crate and the bottom of the crate above." The curing sheds are often covered only as far as the eaves, and the crates are stacked in tiers with space between each tier to allow of a free circulation of air. They are kept there until there is danger of freezing (University of Illinois, Circular No. 173).

Jerusalem Artichokes

Three different vegetables are termed artichokes, the Chinese Artichoke, Globe Artichoke, and the Jerusalem Artichoke. Of these the Globe and the Jerusalem are the most commonly grown. The former is decidedly a garden crop and is cultivated for the sake of the edible

flower shoot, while the latter is valued for the true underground tubers.

The Jerusalem Artichoke (*Helianthus tuberosus*) belongs to the same family as the sunflower, and somewhat resembles that plant in habit, the stems growing very tall, often as much as 6 ft. in height, and they are often very thick. The plant is a very vigorous grower and quite hardy. It rarely flowers in this country.

The tubers show some resemblance to the potato but are usually uneven in outline. In flavour they are sweetish and watery, and though they are quite as nutritious as potatoes there is nothing like the same demand for them. They are not so easily cooked and they are usually considered to be an acquired taste. The prices are generally much higher than for potatoes, and this, together with the heavy yield and comparatively little trouble, makes it a profitable crop.

Generally artichokes are grown in odd corners, as they are not particular as to situation. They may be grown quite successfully in an orchard provided the shade be not too dense. They are sometimes located on land which is too poor or too wet for any other crop, and will often give a remunerative return where no other crop will pay for cultivation.

Artichokes do well in poultry runs, where they usually become perennial and afford welcome shelter and shade. In such situations it is rarely possible to dig up all the tubers, and sufficient small sets are left to continue the crop.

Soil and Situation.

This crop does best on a moderately dry loam, one which will dry up early in the spring being best, but will do quite well on any cultivated soil.

The land should be prepared in the autumn or very early winter, as owing to the very long growing season the crop is usually planted before the middle of March.

Prepare the land as for potatoes, except that any farmyard manure to be given should be ploughed in and not spread in the rows.

Manuring.

Where the land is in good heart little farmyard manure is required. Where necessary from 8 to 10 tons per acre, preferably well-rotted, stable manure is ample, and this, as mentioned above, should be ploughed in in the autumn. This may be supplemented by an application of artificial manure, using the following quantities per acre:

2 cwt. superphosphate of lime.
½ cwt. muriate or sulphate of potash.
½ cwt. sulphate of ammonia.

Dry with steamed bone flour or gypsum (unburnt plaster). Kainit

2 cwt. to the acre or 30 per cent potash salts 1 cwt. to the acre may be used in place of the more concentrated potash compounds, but application should then precede planting by about a fortnight. If no farmyard manure is used increase the above quantities by one-half.

Planting.

Artichokes are planted in January, February, and March, and owing to the great size of the stalks and the consequent shade produced, the rows should run north and south.

The rows should be at least 30 in. apart, and the sets planted 12 to 14 in. in the rows and 4 to 5 in. deep.

The sets may be the small whole tubers or cut sets from large tubers. In the latter case there should be at least two eyes.

The land may be laid up in ridges as for potatoes, the mould board being set shallower and perhaps a trifle wider. In some districts the land is not ridged for this crop. After the land has remained in the rough over the winter it is cultivated and harrowed. The rows are then set out with a marker, usually at 3 ft. apart, and the tubers planted at from 14 to 16 in. apart, using a potato dibber for making the holes, and hoeing to cover.

Satisfactory crops may be obtained on newly ploughed lea. Every fourth furrow—the land being ploughed wide—is turned back and the sets are dropped in at 15 in. apart.

After-care.

There is not much need for vigorous cultivation in growing this crop. It does not need to be earthed up to the same extent as potatoes, and usually cultivation resolves itself into keeping down weeds and conserving moisture. Care must be taken to prevent damage to the stalks, as, if this happens, the plant breaks into a branched head and very few tubers are produced.

The artichoke is much hardier than the potato, being practically unaffected by frost, so long as the tubers are covered with soil. The crop may therefore be left in the ground and dug as required. It is, however, important to get it lifted in February at the latest, as the tubers push into growth very early in the season.

The most common method of lifting is by the fork, though ploughing is quite good. It is very necessary to see that the crop is lifted clean. Pigs are very fond of artichokes and will clean up a crop in a very satisfactory manner.

The greatest drawback to this crop is the difficulty, under poor cultivation, to completely eradicate it once it is planted.

There is only a limited demand.

Cabbage and the Cabbage Tribe

The plants included in this group are borecole (kale), broccoli, Brussels sprouts, cabbage, cauliflower, colewort, and savoy. All these have been produced from the wild cabbage, and in the seedling and flowering stages show marked resemblances, though they do not bear very close likeness to one another during the vegetative growth. In most of the members of the tribe the leaves have been developed to form a more or less swollen bud, but in others the flowering stem has become swollen and a false inflorescence developed.

All these crops are grown for vegetables, and though they vary considerably in constitution and in the treatment necessary, there are certain points in connection with their cultivation which make it possible to generalize on all but details.

They offer a very profitable enterprise to the farmer. There is a constant demand throughout the year and very many acres are devoted to their growth. Proximity to market is an advantage as the crop is rather bulky in comparison with its value, and, in addition, long transit, especially for the finer varieties, makes considerable difference in the quality of the vegetable. In the industrial districts it may only be possible to grow cabbages proper and colewort on account of the smoke and grit.

For most of these crops a rich moisture-retaining soil is essential, and they do exceedingly well on sewage farms. The climate should be cool and moist, and they succeed well near the sea coast. They all do better on a heavy soil than on one which is sandy, and the greatest enemy is drought. Except where the land has become impregnated with finger-and-toe disease a slight acidity of soil is beneficial, and newly broken lea land, if it is sufficiently rich in organic matter, will grow good crops.

As they are all benefited by transplanting, the seed is sown in specially prepared seed-beds, which results in a decided saving in seed.

The three most serious insect pests are the Cabbage Root Fly, the maggots of which destroy the root, and the caterpillars of the Cabbage White Butterfly and the Cabbage Moth, which destroy the leaves. The group is subject to the attack of Club Root, which is analogous to finger-and-toe of turnips, and to Soft Rot caused by a bacillus.

The preparation of the seed-bed, methods of sowing, and mode of transplanting are very similar throughout this group, but they differ in certain details of season, distance, and to a less extent in manuring. Most of them do equally well when the seed is sown outdoors, but early cauliflowers, Brussels sprouts, and cabbages are often sown in heat or in a cold frame where the climate is wet and cold.

Preparation of the Seed-bed.

The soil should be of medium fertility, and a fairly warm situation should be chosen for early work. Nothing is so important as getting a good tilth. Drilling the seed is preferable to broadcasting, and broad drills are better than narrow ones, as the plants then have more chance to grow stocky and upright. Where the drills are narrow it is often necessary to thin out the plants, or to give them a shift to a nursery bed before putting them out into the field. Nothing is lost by this additional shift; in fact it is beneficial and, when the plants are growing too quickly or when it is necessary for other reasons to retard growth, is sometimes imperative.

The drills should not be more than $\frac{3}{4}$ in. in depth, and should be taken out from 3 to 4 in. wide and about 9 in. from centre to centre. A draw hoe is a very suitable implement to open the drills.

Successional sowings should be made, and the same crops are often sown at several different times of the year. There is a very wide range of varieties in most of the species, and certain varieties are favoured in certain localities.

Transplanting the Crops.

It is much better to choose showery weather for this operation, and it is often an advantage to take out a shallow trench where the line is to run. This assists in keeping the plants moist and affords protection to the young plants, and may later be useful for moulding up the stems. On the other hand, in some districts it may be an advantage to ridge the land and plant on the ridges. The distance between the rows, as also between the plants in the row, varies considerably with the different crops and even with the variety chosen.

The plants are either inserted in holes made by a dibber or are forced into the soil by a forked planter. The dibber is the better implement, but the forked planter is quicker. Most gardeners are careful to put the plants in so that the bottom leaves come into contact with the soil, but there does not appear to be any advantage in this.

Tight planting is essential, as the roots and rootlets must come into close contact with the soil before new rootlets are induced, and loose planting militates against this. Where the soil is not well firmed round the plants there is a difficulty in getting them to heart.

Borecole, Kale, or Curly Greens.

This is the hardiest of all the cabbage family, and is usually marketed when there is a dearth of vegetables. The demand is often much better in some districts than in others, and the returns in a mild season may be low.

Borecole is not so demanding in attention as are cabbages, sprouts,

or cauliflower. Though sometimes grown without transplanting, it is much better to have a seed-bed, the seed being sown about the end of March.

The soil should be fairly heavy, good strong well-worked loam suiting this crop best, and should be ready for the reception of the crop not later than the middle of July, as borecole takes a long time to come to maturity, and the market is most profitable in the depth of winter. It is often grown between the rows of crops which will be cleared away early in the summer, and first early dwarf-haulmed potatoes are suitable for this purpose.

Since borecole has to withstand winter conditions, it must not be grown soft, and this entails manuring with the preceding crop. It may follow celery or autumn-sown onions. Where it is impossible to follow a liberally treated crop some manure should be incorporated with the soil in preparation for planting, but care must be taken to use only well-decayed manure, as fresh manure is likely to cause serious loss from frost. Only phosphates and potash should be given as an artificial dressing before planting, but a little nitrate of soda applied just before cutting will hasten maturity and increase the yield.

The distance allowed between the plants and between the rows differs with the variety grown. 2½ ft. between the rows and 2 ft. between the plants in the rows is usual.

In disposing of the crop the young tender shoots command the best price, and are usually marketed in bags.

Varieties.—Sutton's A 1, Cottagers' Kale, Knight's Hearting, M'Gregor's Gathering.

Broccoli.

This is sometimes known as winter cauliflower, but differs considerably from cauliflower in cultivation, the difference being chiefly due to the long time it takes to mature. Broccoli takes from seven to nine months before it is ready for market, while cauliflower may be ready in four months.

There are two different types, white broccoli and sprouting broccoli, and numerous varieties of the former afford a supply over a period extending from November to May.

A rich somewhat sandy loam, but one which is not " light ", is best for this crop, and should be deeply worked. Broccoli, especially in districts where frost is severe, will not stand such generous treatment as may be profitably given to cauliflower, and like borecole the manure should be applied with the previous crop.

The seed is sown in a specially prepared seed-bed from the middle of March to the middle of May, according to district, variety, and the best time to market. For autumn cutting a sowing of an early variety may

be made in March. The main crop should be sown in April for early spring cutting, and a later sowing towards the end of May should be ready for cutting in the following May.

The seedlings are usually carefully thinned or else transplanted to nursery quarters to induce sturdiness, as leggy, drawn plants are never satisfactory. They are transplanted to their permanent quarters in June or July, and the land must be firm to enable the plants to withstand the winter. Broccoli is often planted between the rows of potatoes, and where the latter are sufficiently dwarf in the haulm this is very economical of space. The soil, however, should not be disturbed. Manure as for borecole.

Varieties.—Snow's Winter White, Veitch's Self-protecting, Late Queen, White and Purple Sprouting.

Brussels Sprouts.

Brussels sprouts are usually a very profitable crop, and form one of the best green vegetables during autumn and early winter. They must have a long season for growth, and for this reason it is necessary to get the plants put out early in the summer, so planting-out should not be delayed beyond the middle of June.

While sprouts do best on soil which has been liberally treated, recent manuring is not so suitable as a heavy residue from previous cropping. Soil which has been dressed with fresh manure usually produces sprouts without hearts, and thus renders the crop unsaleable. Firm planting is equally important with this crop, and the object should be to produce short sturdy plants.

Where a succession is desired, sow from the beginning of March till the end of April, and thin-out or transplant to a nursery bed as soon as the plants can be handled. Transplant to their permanent quarters towards the end of May or early in June. Brussels sprouts are sometimes grown between the rows of early potatoes, but this usually makes the plants too drawn.

Varieties.—Aigburth, Perfection, Wroxton.

Cabbage.

This is, next to the potato, the most important vegetable grown, and the area under this member of the group probably equals that of all the others put together.

It is not very demanding so far as soil is concerned, but does best in a deep, rich, retentive loam. Liberal applications of manure, both natural and artificial, are necessary, and the cabbage often enters into the ordinary farm practice to a greater extent than do any of its relatives. It is more easily marketed and the demand is more constant, though prices may not be so high as for cauliflower and sprouts.

The cabbage can be grown more profitably in smoky districts than any of the other members of its group, as the smooth leaf is less likely to be smutted than savoys, and the single head does not hold the dirt so badly as do sprouts.

Where the produce is marketed directly a large number of sowings will be made in the year. Cabbages are in general marketed in bulk during two seasons of the year, from March to July and from September to December. The seasons may, however, be greatly extended by suitable choice of varieties, and in some districts the cabbage is marketed during the greater part of the year.

Cabbages are often grown in the ordinary farm rotation. Hay cut for two years is dressed with dung, about 15 tons to the acre, and ploughed up, to be followed by oats. The land is then treated with 30 tons well-decayed stable manure and cabbages planted. Sometimes these are succeeded by another crop of cabbages the following spring or by spring onions. Wheat follows and the land is laid down to grass. Spring cabbages are often taken after young onions or early peas heavily dressed with manure.

Spring Cabbage.—The most profitable crop is the spring cabbage, the seed of which is sown from the first week in July to the end of August, according to the district. It is necessary to make careful trials to determine the best period for sowing this batch, as if sown too soon the plants may become too forward to withstand winter conditions, while if sown too late they will not be sufficiently well grown to be put out and become established before winter sets in. Where the autumn growing season is very protracted it will be necessary to delay sowing, but where the winter is early and long, July sowing is essential.

The plants may be planted-out from early in September until the first week in October, and some are left in the seed-bed all the winter and planted-out in the spring. The distance apart will vary greatly according to the variety and the demand—from 15 to 18 in. apart each way. Sometimes cabbages are intercropped with coleworts, or cabbages are planted 12 in. apart each way and every alternate cabbage is cut out to bag for greens.

Varieties.—Flower of Spring, Large York, M'Ewan's Early, Wheeler's Imperial.

Summer and Autumn Cabbage.—Summer and autumn cabbages are obtained from seed sown in March or April.

The cabbage is a gross feeder and must have generous applications of well-decayed manure, and also benefits by liberal artificial dressings.

Where Club Root is present, lime or basic slag should always be given in preparation for the crop. Superphosphate may be used where the soil is neutral, and potash is always necessary.

Previous to planting add the following mixture:

3 parts superphosphate 1 to 2 parts sulphate of potash 1 part sulphate of ammonia	applied at the rate of 3 cwt. per acre.

After the winter has passed or when the heads are forming, two applications of nitrate of soda totalling 2 cwt. to the acre may be given.

Varieties.—Early York, Ellam's Early, Enfield Market, Daniel's Defiance.

Cauliflower.

There is usually a very good demand for this vegetable, and that not only for market sale but also for pickling. The earliest cauliflowers are usually forced.

The cauliflower requires deep, rich, well-drained soil, an abundant supply of readily available food, and plenty of moisture. This vegetable has usually to develop very rapidly, hence fresh manure is not suitable. Everything must be done to keep the crop moving, and constant and thorough cultivation is necessary.

Seed is sown in some districts at three seasons of the year:

1. In February or March in a greenhouse or on a mild hot-bed.
2. In April in the open for late summer supplies.
3. In September, outside, for the early spring supplies.

The cauliflower is not so hardy as broccoli, and in many districts it will be impossible to winter it out of doors on account of the wet cold weather. Plants from the September-sown seed are sometimes wintered in shallow frames and planted-out as soon as the weather is mild enough. Summer supplies are provided for by the seed sown in the frames in February, and those from the outside seed-beds supply the autumn market.

The earliest varieties are usually much smaller than the late ones, and the distance at which they are set therefore varies considerably, ranging as it does from 24 in. by 18 in. to 30 in. each way. Cauliflower is frequently planted between the rows of peas (dwarf or on sticks) and is also often intercropped with spinach, lettuce, celery, &c.

Abundant supplies of quickly available food and a constant supply of moisture are the critical factors, and for this reason a soil mulch should be maintained. Manure as for cabbage.

As soon as it becomes necessary, a leaf should be broken over the developing "flower" to protect it from sun and dirt.

Varieties.—Early: Early London, Snowball. Later use: Dwarf Erfurt, Late Paris, Walcheren, Veitch's Autumn Giant.

Savoy.

This is chiefly a winter vegetable and bears a close resemblance to the cabbage, but the leaves are crinkled instead of being smooth. For this reason the savoy is not suitable for growing in districts where there is much fog or smoke. The soil should be in as good heart as for cabbages.

Three sowings will possibly be necessary to provide a sufficiently extended crop, the first about the middle or end of March, and the last at the end of April. Plant out the earliest sowing in June, and the others as circumstances permit. Transplanting should only proceed in showery weather.

The dwarf varieties may be planted 15 in. apart each way, while the drumheads will require anything from 2 ft. to 2½ ft. apart.

Varieties.—Dwarf Green Curled, Drumhead, Ormskirk.

Insect Pests and Diseases.

All the cabbage family suffer from attacks by the Cabbage Root Fly, which lays its eggs at the side of the root and from which maggots hatch to destroy the roots of the plants.

This pest can be controlled by using corrosive sublimate, 1 oz. to 10 gall. of water, and pouring ¼ pt. of this round each plant after setting out in the field. The powder dissolves more readily in hot water than in cold. Extreme care must be exercised in using the material to see that none of the powder is spilled or any of the solution left about.

For caterpillars of the Cabbage White Butterfly or the Cabbage Moth attacking the plants while young, arsenate of lead paste, 2 lb. to 40 gall. of water, should be used, but not within six weeks of marketing.

The best corrective for Club Root is lime, 10 cwt. to 1 ton per acre.

Fungous Diseases of Vegetables and Fruit

The parasitic fungi play a very important part in determining the success of the vegetable and fruit grower, and his success is becoming increasingly dependent upon his ability to avoid or control the diseases which can affect his crops.

Anything which interferes with the normal development of a plant is really a disease, and the ability to detect any variation from the normal during its early stages is a great asset. The manifestation of disease in enlarged, deformed, or stunted growth is due to the reaction of the plant to the abnormal conditions, and these may be due to improper cultural methods, bacterial activity, insect attack, or to the presence of parasitic fungi.

For a long time it was thought that bacterial attack was not common among plants, but unfortunately that is not the case. The number of diseases attributed to bacterial orgin is constantly increasing and includes some of the most destructive diseases known. Fungous attack is more easily recognized than is bacterial attack, as the fungi usually show their presence by the production of mycelium, sporing bodies, and other structures visible under a lens. In the case of bacteria, however, indentification can only be determined by the reaction of various culture media.

A fungus usually possesses a mycelium—the vegetative part, which passes into the host plant or develops superficially and sends out short hyphæ which penetrate the cells and extract food material therefrom. Sometimes, as in the case of Eutypella, the mycelium penetrates deeply into the tissues of the plant, passes into the vessels, and cuts off the water supply. For reproductive purposes the mycelium generally develops short branches which push through the epidermis of the host plant and bear the spores terminally or laterally.

The spores vary considerably in size, shape, and duration in the different species and even in the same disease. There are two great classes of spores—the summer or conidial spores and the winter or resting spores, the latter being often formed in a special structure, the perithecium, but all the fungi do not show both these forms. The epidemic stage is usually induced and spread by the conidia, while the disease is carried over from one season to the next by means of the winter spores, sclerotia (concentrated masses of mycelium), or by hibernating mycelium situated within the host.

Disease spores are spread by various agencies, such as wind, water, insects, birds, contaminated soil or seed, &c., and by the distribution of diseased plant parts. One of the most essential preventive measures is the complete incineration of all diseased material. During the conidial stage myriads of spores are produced, and these, having fallen on a suitable host, under moist conditions germinate and produce an infective tube which penetrates the plant and sets up disease.

Many of the more highly specialized fungi can only infect one particular type of plant; thus the mildew of peas cannot attack beans and the mildew of beans cannot affect vetches, yet all these plants are affected by mildews which have similar outward characters.

Fungous attack shows itself in various ways, and the effect may be noticeable on the root, stem, leaf, flower, or fruit.

On the leaves disease may produce:

1. Spots or holes which may be regular or irregular, circular or elongated, and may be definitely margined or fade imperceptibly into the unaffected tissue.

2. Leaves which become sickly and poorly developed, and this may be followed by defoliation, e.g. Eutypella.

3. Wilting of the leaves or blossom trusses, e.g. Wither Tip.

4. Rusts on leaves or fruit which may appear as yellow or reddish spots, regularly or irregularly distributed.

5. Mildews where the leaves and other parts are covered with a white or greyish mycelium, quite superficial, which may or may not darken with age, e.g. American Gooseberry Mildew.

On the fruit the effect is usually shown by:

1. Spots or scabs more or less regular in outline and often broken by numerous fruiting organs, e.g. Apple Scab.

2. Pits or sunken areas where the underlying tissue has been destroyed, e.g. Apple Bitter Rot.

3. Rots which may be wet or dry.

On the stems and branches the disease may produce:

1. Dead twigs, e.g. Wither Tip.

2. Canker areas, usually depressed, and the stem may be completely girdled, e.g. Apple Canker.

3. Galls and enlarged outgrowths, e.g. Club Root.

Control of Fungous Diseases.

1. Clean cultural methods and observance of a rational rotation are very important preventive measures. Diseases are often much worse where weeds are plentiful. Since many fungi can only attack one particular kind of crop or allied crops, a change of crops is often beneficial. Land which is impregnated with Club Root of cabbage would not be suitable for turnips, but onions could be grown without any danger of similar attack.

2. Many diseases of seedlings are more severe when the plants are overcrowded than when air and sunlight can pass freely among the plants.

3. Certain fungi are wound parasites and cannot enter through an unbroken surface, e.g. *Nectria cinnabarina*. Dressing pruning and other wounds with anti-fouling paints, tar, and other materials, and the suppression of insect pests lessens the possibility of infection.

4. Complete destruction of all diseased materials. One of the surest methods of reducing an infestation of Brown Rot of plums is to gather and burn all affected fruit, both from the ground and from the trees, and to cut off and burn all diseased twigs.

5. Total destruction of the worst affected trees or plants may sometimes be advisable. Certain varieties of apples are very susceptible to Apple Scab, and the removal of one tree may lessen the future attack.

6. Some fungi pass one stage of their life-history on one plant and the remainder on another, so the destruction of the intermediate host may remove the disease. Gooseberry Cluster Cup passes one stage of its life-cycle on the gooseberry and the other on rushes and sedges.

7. Growing immune varieties. In certain cases it has been found

possible to overcome diseases by using resistant or immune varieties, and the selection and breeding of such varieties or root stocks is now one of the chief methods of disease control.

8. Spraying with fungicides. This is usually a preventive and not a curative measure, as when the disease has gained a firm hold on the crop spraying is of little avail.

9. Disinfection of seed or soil or both.

Fungicides, Spraying, &c.

The most important fungicides are various compounds of sulphur, copper, or acid derivatives of hydrocarbons such as cresylic acid and formaldehyde.

1. *Sulphur.*—This is used in the form of a fine powder and varies considerably in fineness and in price. Ground sulphur, flowers of sulphur, and wind-blown sulphur are the most suitable forms of dry sulphur. Colloidal sulphur, which must be applied wet, will probably become the most satisfactory source of sulphur, but at present the price is prohibitive.

Dry sulphur is used for various mildews, e.g. Strawberry Mildew and Vine Mildew. The sulphur is either applied by hand or by means of a sulphur bellows. For strawberries a dressing of ¾ cwt. per acre is given, and it is customary to choose damp weather so that the sulphur will adhere to the leaves. Repeated applications are necessary as the leaves develop.

2. *Lime-sulphur.*—This is a commercial preparation obtained by boiling lime and sulphur with water. The value of the material depends on the proportion of sulphides and polysulphides of calcium contained in the solution. Home-made lime-sulphur is very unsatisfactory, and certain commercial preparations leave much to be desired. The only guarantee usually given with lime-sulphur is that it has a specific gravity of not less than 1·3, and growers should purchase those brands which contain the highest percentage of polysulphide-sulphur.

Lime-sulphur is used both for summer and winter spraying, and for dormant plants or trees a much stronger solution may be used than during the growing season. For winter spraying of fruit-trees and bushes the strength varies from 1 gall. of lime-sulphur to 9 gall. of water (1 in 10) to 1 gall. to 19 gall. (1 in 20) respectively. For summer application a strength varying from 1 in 40 to 1 in 60 is used according to the nature of the plant.

Lime-sulphur is used at winter strength for cleaning fruit-trees and bushes and for Big Bud of black currants, and at summer strength for American Gooseberry Mildew, Brown Rot, Wither Tip, Apple Scab, Strawberry Mildew, and other diseases. Certain varieties of gooseberries, such as Crown Bob, Lancashire Lad, and Early Sulphur, will not stand as strong a solution as Whinham's Industry, and for those a dilution

of 1 in 60 is used. Lime-sulphur may produce a russeting effect on the leaves and fruit of some apples, and Cox's Orange Pippin, Lady Sudeley, and White Transparent should not be sprayed with a stronger solution than 1 in 60 while the fruit is on the tree.[1]

Compounds of Copper.

1. *Bordeaux mixture.*—This is not now so commonly used for fruit as was formerly the case, owing to the scorching effect of the material, some varieties of apples, for instance, being very susceptible. It is made by mixing a solution of copper sulphate with lime wash or lime water. The 1-per-cent mixture contains 4 lb. copper sulphate and 4 lb. quicklime to 40 gall. of water. For fruit a 0·8-per-cent solution (4 : 4 : 50) is used, while for vegetables a 1-per-cent solution is more common.

To make a 1-per-cent solution. Two wooden vessels, one a paraffin barrel (40 gall.), will be necessary. Put 10 gall. of water in the smaller vessel (if there is any difference in size) and add to this 4 lb. of finely ground copper sulphate. For preference the copper sulphate should be placed in a closely woven bag and suspended just beneath the water. In the other vessel place 4 lb. of quicklime and add just sufficient water completely to slake, as an excess of water prevents the total disintegration of the lime. More water should be added as required and the whole made up to 30 gall., after which the copper sulphate solution should be poured into the milk of lime. The solutions must be cold before being mixed, but Bordeaux mixture will not keep and must be used at once.

2. *Burgundy mixture.*—In this case the lime is replaced by carbonate of soda (washing soda). 4 lb. copper sulphate and 5 lb. carbonate of soda to 40 gall. of water give a 1-per-cent solution. In this case the copper sulphate is dissolved in the larger barrel in 30 gall. of water and the soda solution poured in. Hot solutions must not be mixed.

For Bordeaux and Burgundy mixtures a clean wire nail is a good test.[2] If it remains bright when dipped into the clear solution sufficient lime water or soda as the case may be has been added, but if the nail becomes dull more of the respective alkali should be stirred in. The most reliable test is potassium ferrocyanide, a solution of which will give a chocolate precipitate if there is any free copper in the clear solution.

There are several proprietary articles on the market which might be used in place of Bordeaux or Burgundy mixtures made as above.

3. *Copper sulphate.*—This is a winter wash for fruit-trees, but must not be used for plants in leaf. After an application of caustic soda, copper sulphate is often used at the rate of 1 lb. to 10 gall. of water. More

[1] "The employment of caseinate spreaders with lime-sulphur has been found to increase its efficacy. Lime-sulphur may be diluted with twice the quantity of water when these are used, and no scorching need be feared."—Parker and Long.

[2] Spencer Pickering. *Science and Fruit Growing.*

dilute solutions, 1 lb. to 20 gall. of water, are also used for Apple Scab, Brown Rot, and Die-back of gooseberries.

4. *Ammoniacal copper carbonate.*—This is used for watering seedlings in pots or seed-beds to prevent damping-off. 2 oz. finely powdered copper sulphate are mixed with 11 oz. finely crushed lump ammonia, and the mixture placed in a glass jar with a tightly fitting lid, which should remain undisturbed for forty-eight hours before use. Use the mixture at the rate of 1 oz. to 2 gall. of water. (Cheshunt Compound.)

In addition to the foregoing compounds of copper, the following substances should be mentioned:

Formaldehyde (formalin).—The commercial preparation contains 40 to 42 per cent of formaldehyde. It is used chiefly for soil sterilization and for seed disinfection. The seed should be soaked in water for six hours previous to treatment. Dilute formalin with 240 parts of water.

Corrosive sublimate.—This is a very deadly poison and great care must be exercised in its use. At a strength of 1 in 1000 it is sometimes employed for seed disinfection.

Mixture for painting trees as a preventive against Eutypella.—Soft soap is reduced to the consistency of thick paint by the addition of a solution of washing soda (½ lb. to the gallon of water). For every 5 gall. of the mixture so made, 1 lb. of slaked lime is stirred in. Smear over the stem and all cut surfaces on the branches.

Spraying.

No operation is of greater importance than spraying plants and none is so imperfectly understood. The popular idea that the desired result is obtained by the use of excessive quantities of solution is erroneous. In using fungicides especially, the object should be to deposit a very thin film of the mixture or solution over the part sprayed, so that entry of fungus spore-tubes is prevented, and the materials used can by the large surface exposed exert the maximum toxic effect on the mycelium or other parts of the fungus with which the spray comes into contact. When sprays are applied so that the plants drip, very little of the material adheres to the leaves or other plant parts, while owing to the drying out of the globules severe scorching may result.

A fine nozzle capable of producing a fine, mist-like spray, attached to a machine where adequate pressure can be maintained, is necessary. Owing to the continued production of new foliage it may be necessary to spray several times during the season. Various materials have been tried to give greater adhesiveness.

In using lime-sulphur it will be necessary to cover the hands with a coating of vaseline or to use rubber gloves.

N.B.—Lime-sulphur must not be used in copper vessels as it destroys

the metal. Where brass machines are used these should be carefully washed before being stored.

Apple Canker (*Nectria galligena* (*ditissima*)).

This attacks both apples and pears, and some varieties show a marked susceptibility to the disease, especially on wet soils and where the rainfall is high. Bramley's Seedling, Early Victoria, Grenadier, Lane's Prince Albert, and Newton Wonder are fairly resistant.

Life-history.—The first symptom observable is the cracks which appear in the bark of the old or new wood and which are characteristic. The cracks are usually concentric, and the mycelium later travels under the bark and may completely girdle the branch. The cankers are often swollen and a ragged callus is formed round the wound. In February, red spores of the disease may be observed in the old canker wounds. Woolly Aphis is said to carry the disease from one place to another.

Control.—1. Old cankers should be cut out completely so that only healthy wood shows, and the wound dressed with coal-tar or anti-fouling paint.

2. Spraying the trees with lime-sulphur early in the spring or with copper sulphate or Burgundy mixture in winter has given encouraging results.

3. Keep down Woolly Aphis.

Apple Bitter Rot (*Glomerella rufo-maculans* (*Glœosporium cingulatum*)).

This disease is very widespread and causes serious loss in the apple crop. It also attacks pears, peaches, and cherries. The most noticeable effect is seen on the fruit, but the disease also affects the twigs and branches.

Life-history.—The first symptom on the fruit is the occurrence of one or more small, light brown spots just beneath the skin of either the almost mature or the immature fruit. The spot gradually enlarges and *always has a fairly definite outline, is circular in shape, and remains firm.* The affected area increases and shows a sunken region and becomes darker in colour, thus accentuating the clearly defined circular margin. The conidia borne on these sunken areas form pink cushions and show up strikingly against the black background.

On the twigs the disease shows as cracked, burnt-looking patches which are probably the most dangerous source of infection for the fruit the following year.

The development of the pink cushions is much more noticeable during moist than during dry weather, and under those conditions the whole area affected shows concentric circles of spores on the fruit. The affected fruits may decay but as a rule remain firm, and either fall to the ground or else become mummified on the plants. These dried fruits are usually

covered with the spores of the disease, and these spores retain their vitality over the winter.

The mycelium of the fungus pushes its way beneath the skin of the apple and disorganizes the tissue, and the hyphæ send up conidiophores which produce the conidia. The conidia are washed from the fruits on to other apples or may be carried by insects. Under favourable conditions these spores germinate and set up infection by means of a germ tube capable of penetrating the uninjured skin of the fruit. On the branches, entry is usually gained through wounds and cankers caused by other diseases.

Control.—1. Hand picking. Where possible all affected fruit should be picked and burnt as early as it can be detected. All fallen fruit and all mummified apples should be gathered and similarly treated.

2. Four sprayings with Bordeaux mixture as follows: (*a*) just before the buds burst; (*b*) 4 to 5 weeks afterwards; (*c*) two further sprayings at intervals of ten days.

Apple Brown Rot (*Sclerotinia fructigena* (*cinerea*)).

This is the same fungus that causes Wither Tip and Blossom Wilt.[1] The disease is very prevalent, and also attacks plums, cherries, peaches, and apricots. On the apple it differs somewhat from Bitter Rot in its effect, and usually occasions the complete decay of the affected apples, which turn brown.

Life-history.—Infection takes place during the summer, and diseased specimens show small brown spots which rapidly involve the whole fruit, turn blackish, and cause the fruit to become soft and wrinkled. Pustules form from collected mycelium of the fungus, burst through the raised spots which appear on the fruit, and present a powdery appearance.

The diseased fruit has a characteristic appearance with its concentric circles of white fluffy spores, and usually falls to the ground, but in some cases remains mummified on the trees. On the limbs and branches cankers are produced. See *Plum Brown Rot* for control measures to be adopted.

Apple Mildew (*Podosphæra*).

This disease, which is becoming increasingly important and widespread, first shows on the young shoots, which appear to have been sprinkled with flour. The under surface of the leaves shows definite masses of powdery material, and these are also present on the petioles and young twigs. Mildew interferes with the normal development of the leaves and the shoots; the latter remain stunted and the former fall prematurely. The fungus is developed superficially and the nourishment is abstracted

[1] H. Wormald, D.Sc., *Journal of the Ministry of Agriculture*, July, 1923.

from the plant by means of haustoria (suckers) which penetrate the cell walls.

Life-history.—The mycelium of the fungus is found in the summer on the leaves and young shoots, and penetrates the cell walls by means of haustoria and forms numerous chains of white oblong conidia.

The ascigerous condition is rare, but may develop on the mycelium in the form of darker coloured perithecia with long unbranched appendages arising from the apex and wavy branched ones from the base. The disease more usually winters by means of hibernating mycelium.

Control.—1. All affected shoots should be cut away.

2. Spray in early spring with lime-sulphur, 1 in 12, or copper sulphate, 1 lb. to 10 gall. water.

3. After the buds have burst, spray with Bordeaux mixture, 1 per cent, or lime-sulphur, 1 in 40.

Apple Scab (*Venturia inæqualis*).

This is probably the most common disease of apples, and though it does not cause the decay of the fruit as is the case with Bitter Rot and Brown Rot, it lessens the value considerably and interferes with the keeping qualities. In addition, the growth of the shoots and the development of leaves are affected, certain varieties being in these respects much more susceptible than others. Bismarck, Cox's Orange Pippin, Grenadier, Lord Suffield, Mr. Gladstone, and Wellington are very susceptible, while Bramley's Seedling and Lane's Prince Albert are less liable to scab.

The degree of attack also varies considerably with the variety, and the disease may damage the fruit either by causing distortion and reducing the size, or in certain cases by producing cracks almost to the core. An attack of scab is often followed by development of other trouble.

Life-history.—The first appearance of the disease may be observed on the leaves in spring in the form of small faint olive brown nearly circular patches, chiefly on the upper surface. These spots increase in size, run together, and later may show a dead centre.

On the fruit the attack is usually first seen as a small grey circular spot which later becomes blackish. The affected area increases in size and the skin of the apple dies. As the season advances, the scabby patches become somewhat smoothed and the apple is less unsightly. In very early and severe attacks the spots run together and cause deformed fruits.

The shoots serve as the source of infection for the leaves, and from the leaves the disease spreads to the fruit. It shows its presence on the shoots in the form of wrinkled bark-fissures and dead patches on which spores are borne freely, and carried by the wind to the young leaves; it there produces the infection which in turn occasions the attack of the

fruit. The disease is also carried over the winter by the ascigerous condition on the old withered leaves.

Control.—1. Cut out affected shoots.

2. In February or March spray with lime-sulphur, 1 in 10.

3. Just before the blossoms burst, spray with half-strength Bordeaux mixture.

4. After the blossom has fallen, spray with either half-strength Bordeaux mixture or lime-sulphur, 1 in 50.

Pear Scab (*Venturia pirina*).

This is very similar to the scab of apples, except that it often appears earlier than the latter and causes the fruit to fall very prematurely. In bad attacks the fruits are usually cracked.

Control.—1. Remove diseased shoots.

2. Just before the buds open, spray with lime-sulphur, 1 in 12.

3. Before the blossoms are fully expanded, spray with lime-sulphur, 1 in 50.

Pear Leaf Spot (*Mycosphærella sentina*).

This disease, causing defoliation, is much more dangerous to young trees than to old, and is occasionally very troublesome in nursery stock.

Life-history.—The leaves show, on the upper surface, minute purplish spots which later become grey with a brown border. The spots are well defined, slightly angular, and rarely more than a quarter of an inch in diameter. In the centre the fruiting bodies develop later, and may be seen with a lens as small black points, usually on the under side of the leaf.

The ascigerous condition is developed on the dead leaves, and re-infection takes place from this source the following season.

Control.—After the blossom has fallen, spray with either half-strength Bordeaux mixture or lime-sulphur, 1 in 50.

Valsa (Eutypella) prunastri, Pers.

Very serious loss amongst young plums and apples is caused by this fungus. It is more troublesome as a rule with plums than with apples, and Victoria appears to be the most susceptible variety. In some districts hundreds of plum trees succumb every year to this disease.

Life-history.—The trees may die during their first, second, or third year after planting, but often remain quite healthy up to their first or second year of fruiting, when one branch, after the foliage and blossom has appeared, commences to die back, the leaves, which are small and yellow, shrivel and turn brown, and the fruitlets persist. Later the whole branch is found to be killed, and the following year a second or third

branch is attacked. The tree dies usually within three years of the time the disease manifests itself on any branch.

A young tree when affected shows a moderate development of leafage which later turns brown, and at the same time there is generally an abnormal growth of shoots or suckers below the point of attack. The fungus is a wound parasite which, having gained entry into the tree, cuts off the water supply owing to the development of mycelium in the vessels. Later, sunken blackened areas occur where the mycelium is most active, and from May to July numerous dark coloured raised points appear on the bark; these are the openings to the spore cases.

Control.—1. Since the disease is a wound parasite, care must be taken to trim carefully all broken surfaces.

2. Young trees should be coated along their stems with a mixture to prevent the entry of fungi (see *Fungicides*).

3. Much benefit results from the painting over of all cut surfaces, &c., with certain anti-fouling paints, one free from arsenic being preferable. The painting over of exposed surfaces on or near the main stem or larger branches is not a serious commercial proposition, and growers would be well advised to see that this is carried out.

4. No spraying methods are likely to prove effective.

Plum Pockets (*Taphrina pruni* (*Exoascus pruni*)).

This disease is closely related to Peach Leaf Curl and to the Witches Brooms on cherries, and is not very common, but where it does occur may cause very serious loss.

Life-history.—About a month after the blossom falls the small half-grown fruits appear abnormal in colour and of excessive size. Later the fruits become wrinkled and elongated, and on examination the stones are found to be very small or entirely absent. The difference in size between the affected and non-affected plums is very noticeable, and the former are spongy in texture. Diseased fruits turn black and rattle when shaken.

On the plums may be seen the fruiting stage of the fungus. The spores infect adjacent shoots and the threads of mycelium ramify through the twigs and are there persistent. In the spring the hibernating fungus grows out, forming infection threads which pass into the blossoms and feed upon the tissues, thus causing the abnormal growth or " bladders ". The fungus produces numerous asci on the fruit, the ascospores from which blow about and infect the shoots.

Control.—Since the fungus is persistent in the shoots, spraying alone is not satisfactory. All affected shoots should be removed, and twigs and shoots carrying bladder plums should be cut off and burnt.

Silver Leaf (*Stereum purpureum*).

This disease has caused tremendous loss amongst plum trees, and also

affects apples, peaches, apricots, gooseberries, and currants. Up to the present it has been much more important so far as plums are concerned, but is now spreading rapidly among apple trees. This disease is notifiable both in England and Wales and in Scotland.

Some doubt exists as to whether the fungus *Stereum purpureum* is always the cause of the diseased condition known as Silver Leaf, but there is no room for doubt that the spores of the fungus mentioned can produce this condition. Whether infection can only be caused by means of the spores of the fungus—produced only on the dead wood—is not so certain.

Life-history.—Although the fungus may be found in the stems and branches, the leaves only show evidence of attack at first. Such leaves are normal in size or only slightly dwarfed, but possess a decided silvery or leaden appearance.

It rarely happens that the whole tree—except in young stock—shows the infection the first year. Usually one branch is affected; this is killed later, and successive branches are killed until eventually the whole tree dies.

The fungus fructifies on the dead wood in the form of more or less flat plates which at first are purple in colour. These are sometimes crowded together, but there is no definite arrangement. In size the plates vary from a quarter of an inch to inches in diameter, and after exposure they lose their bright colour and shrivel. From the exposed surface, spores in profusion are liberated, and these gain entry through a wound and infect other trees. The fruiting stage is found during the spring, so if all dead wood be removed and burnt during the winter the chance of infection is greatly lessened thereby.

A good deal of investigation has been carried out on this disease, but so far no cure has been found. Much benefit may be derived in the early stages from the application of quick-acting nitrogenous manures which may stimulate the trees and prevent the further development of the fungus. Apple trees recover much more readily than plums. Not all plums are equally susceptible, the two varieties most liable to attack being Victoria and Czar.

At the present time experiments on stocks with a view to the production of immunity are being carried out at East Malling, and these show that much may be done by the use of suitable stocks to lessen the outbreak.

Plum Brown Rot (*Sclerotinia fructigena* (*cinerea*)).

Plum Brown Rot, Blossom Wilt, and Wither Tip are all closely related diseases, and if not caused by the identical fungus represent different phases in the life-history of a similar parasite. In the Brown Rot stage the fruit is ruined and withers up, usually to form mummified fruits. In the case of Blossom Wilt the blossom trusses and the young shoots are

killed, while in the Wither Tip stage, which is found together with the others, the leading shoots are killed.

This disease is greatly on the increase, and a biological species affects apples. Whole areas sometimes show very bad infection of the blossom trusses and twigs, and the trees present a very unhealthy appearance in the spring and early summer. Later the trees seem to grow out of it, more foliage is produced, and the trees take on a healthier look. The grower is lulled into false security by this apparent disappearance of the disease, and precautionary or remedial measures the following season are again neglected.

Life-history.—The disease kills out fruit trusses and fruit buds, and long straggling shoots, without any fruiting spurs, result.

Infection takes place through the leaves and young blossoms, and the young growths are entered, causing the water supply to fail and the tips to die.

The fruiting stage of the fungus is to be found in autumn on the fruit, where it may be seen as a grey mould covering the more or less dried plums. Often a bunch of four or more plums will be affected and show a covering of the fungus spores. Such fruits later shrink and become a bunch of mummified plums on which the spores continue to form and serve as a source of infection the following year. Spores are also produced on the withered tips the following spring.

Control.—1. Gather and burn all mummified fruit.

2. Cut over and burn all tips which are affected.

3. Spray with soft soap, caustic soda, and copper sulphate before the buds burst.

Gooseberry Die-back (*Botrytis cinerea*).

This disease is very prevalent and often passes unnoticed. It tides over the winter in the form of sclerotia which are hard, and it is thus very difficult to suppress.

Life-history.—The attack generally takes place at or near the ground-level, entrance being gained through a wound, and the bush presents a characteristic appearance. The leaves usually expand and then on the whole or a part of the bush (dependent on the point of attack) they begin to wilt and curl. Later the affected portion shows brown, dead, curled leaves.

When entry is gained just above the ground-level in a single-stemmed bush, the death of the plant results. For this reason growers would be wise to see that the young bushes are not single-stemmed.

After the death of one branch the fungus may travel to attack another branch and pass up to the tip of this. The point of attack afterwards shows the bark curled back, on which cushions of small grey spores appear in autumn and in spring. These spores can cause infection of other

bushes in the following growing season. The disease is also handed on by concentrated mycelium—the sclerotia.

Control.—1. Cut out and burn all affected twigs and branches before the fruiting spores are formed.

2. Spray during late winter with soft soap, caustic soda, and copper sulphate.

3. After the fruit has formed, spray with Bordeaux mixture.

Where lime-sulphur is already being used for suppressing American Gooseberry Mildew the only other treatment necessary would be the cutting out and burning of affected branches.

American Gooseberry Mildew (*Sphærotheca mors-uvæ*).

This disease bids fair to make impossible the growing of gooseberries. It is widely distributed, and most stocks in Holland and many in this country are contaminated. The disease is a notifiable one, and in their own interests growers should take active measures to stamp it out wherever it occurs.

Life-history.—The first symptom of infection is the occurrence on the young leaves of a delicate white web-like mycelium, and this later covers the shoots and may spread to the berries. This stage usually appears about the end of May, and later becomes much more dense and darkens somewhat in colour. Clouds of minute spores or conidia are formed on the web, and these may be borne by the wind and cause infection of adjacent shoots and bushes.

As the season advances the white web becomes brown and develops into felt-like areas—the most noticeable stage. The winter spores are found embedded in the felt-like matrix, and the disease hibernates in this manner and reinfection takes place the following year. The young shoots and berries are more usually seen with this brown stage than other parts of the bush.

The effect on the bush is seriously to check the growth, and to cause the berries to be deformed and rendered unsaleable owing to their repulsive appearance.

Gooseberries are also affected by European Gooseberry Mildew (*Mycosphærella grossulariæ*), and in some cases this disease, which is not so serious, may be mistaken for American Gooseberry Mildew, but this error can only occur in the conidial stage. In European Gooseberry Mildew the berries are very rarely affected and the brown felt is never present. Both mildews are often found on the same bush.

It is usually considered that American Gooseberry Mildew passes the winter in the form of the asci which fall to the ground, and that those asci which remain on the bush are sterile.

The disease is said to be favoured by moist dull weather, though moist districts are not more susceptible to attack than dry districts. Soft

sappy wood is always more likely to be attacked than short well-ripened shoots.

Control.—1. All young tips which show the felt-like mycelium should be removed and burnt early in the autumn, or even as soon after picking as possible, and be followed by a spray, using lime-sulphur, 1 in 40.

2. As late as possible in the early spring—March or April—spray with lime-sulphur, 1 in 12. This is in any case a useful red spider treatment and should be given just as the buds burst.

3. During summer, two or three sprayings with lime-sulphur, 1 in 40, should be given as follows: (*a*) just after the leaves are fully out; (*b*) after the blossom has set; (*c*) when the berries are half grown.

Certain varieties of gooseberries, noticeably Crown Bob and Keepsake, *will not stand lime-sulphur 1 in 40*, so for these and some other tender varieties 1 in 60 should be used. Lime-sulphur leaves a sulphur deposit on the fruit, and potassium polysulphide (liver of sulphur) is sometimes substituted for this in the last spraying.

Strawberry Mildew (*Sphærotheca humuli*).

Strawberry Mildew attacks most varieties of strawberries, seriously retarding the growth of the plants, and is usually more prevalent in dry weather.

Life-history.—This disease is easily identified by the characteristic turning back of the leaves so as to expose the lower surface. The attack is most serious in the young plants, and will often prevent the crowns developing in a normal manner. The fruit may also be affected, and when this is the case it rots or becomes unsaleable owing to the peculiar watery appearance.

If the affected leaves be examined, a web of delicate mycelium covered with white powdery material will be seen. This is the conidial stage and causes the rapid spread of infection.

Later in the season the perithecial form may be found, and it is this which forms the hibernating stage of the fungus. The disease can pass the winter on certain weeds, and for this reason the strawberry beds should be kept clean.

Control.—1. Before the blossoms appear spray with lime-sulphur, 1 in 50.

2. After the blossom has commenced to set, and again ten days later, spray with lime-sulphur, 1 in 60.

It will be necessary to coat the successive bursts of foliage.

3. Or dust three times with flowers of sulphur.

Grey Mould of Strawberries (*Botrytis cinerea*).

Much of the damage caused by this fungus is often attributed to mildew. The fruit is covered with a grey mould which causes it to rot.

The attack is usually greater in a wet season than in a dry one, and is worse in a variety which carries its fruits near the ground and close together. Berries are often affected when they come into contact with the ground or with a straw mulch.

Treatment as recommended for mildew should prevent this disease.

Strawberry Leaf Spot (*Mycosphærella fragariæ*).

This disease is more prevalent in dry districts than in wet ones.

Life-history.—Equally noticeable on both surfaces of the leaves may be seen very small dark red spots which enlarge and the centres become white looking, like round eyes. The conidia develop on these spots on both sides of the leaves and blow about and infect new leaves.

Perithecia are formed in the autumn, and these liberate the winter spores in the spring. The fungus can also persist in the form of sclerotia and by hibernating mycelium.

Control.—The affected leaves should be removed when planting up new beds.

No satisfactory method of suppression has been found, but treatment as for Strawberry Mildew will do much to lessen the attack.

Club Root (*Plasmodiophora brassicæ*).

Serious loss of cabbage and allied crops is often due to this fungus. The trouble is identical with finger-and-toe of turnips, though on the cabbage the swelling is more pronounced.

Life-history.—Swellings may be seen on the main root or the laterals (or both), and these may be distinguished from those produced by eel-worm by their large size. Infection takes place during the seedling stage. The germinating spore in the soil infects one of the root cells of the plant and stimulates this and the adjacent cells. The cells both of the fungus and the host plant divide repeatedly, the former increasing the region of infection and the latter causing the enlargement of the affected part.

Within the affected cells numerous amœboid organisms are produced, and these fuse to form a plasmodium which later divides to form numerous spores. On the decay of the root these spores are liberated in the soil and on germination are capable of infecting the root hairs of cruciferous plants. The organism is favoured by acid and retarded by alkaline conditions of the soil.

Control.—1. Since seed-bed infection is the rule, dress the seed-beds with lime, using shell or ground lime at the rate of 1½ to 2 tons per acre.

2. Do not transplant affected plants.

Cabbage Black Rot (*Pseudomonas campestris*).

This rot is caused by a bacterial disease and often entails the entire

loss of the crop. The infecting spores remain in the soil for several years, and this prevents the use of the land for similar crops. The disease is known to affect practically all cruciferous plants.

Life-history.—The leaves first turn yellow and then brown, and if a section be cut through the midrib of the affected leaf the vascular bundle shows as a black ring owing to the presence of numerous bacteria. The water supply is cut off and the part affected collapses. Infection is said to take place through the water pores on the margin of the leaves.

Control.—1. Slugs, caterpillars, and other insects, various forms of animal life, and even human agency spread the spores.

2. Seed is often contaminated with the spores and may be disinfected by soaking for fifteen minutes in corrosive sublimate, 1 in 1000, or by the formaldehyde treatment (1 in 240 for fifteen minutes).

3. Where the disease has occurred burn all affected material and keep cruciferous plants off the land for two years.

Stem Rot of Cabbage (*Phoma brassicæ (oleraceæ)*).

Life-history.—Dark brown, sunken areas appear on the stem of the plant, usually near the ground, and the plant later collapses owing to the secondary effect of bacteria. On the affected parts the pycnidia may be seen bursting through the epidermis.

Control.—1. Remove and burn all plants showing symptoms of attack.

2. Following bad attacks employ seed disinfection.

Damping-off of Brassicas (*Olpidium brassicæ*).

Life-history.—The young seedlings are attacked by this and various other fungi which cause the collapse of the stem at or near the ground-level. A single swarm-spore invades the tissue of the host, often gaining entry to a deeply seated cell, and, after forming a cell wall, divides later on and liberates zoospores into the soil. Resting spores are also formed.

Control.—1. The seed should be disinfected.

2. This disease is always more troublesome in seed-beds which are sown too thickly, and thinning-out and sunlight are the best preventives.

3. Where the disease has appeared it may be advisable to water the succeeding beds with Cheshunt Compound. Seed-beds may before sowing be treated with formaldehyde.

Onion Mildew (*Peronospora schleideni*).

This disease does not cause the onions to decay, but by attacking the leaves retards the development of the bulbs.

Life-history.—The disease first appears late in June or in July in the form of white patches on the leaves. These patches later show a violet tint, and on close examination are seen to be covered with a downy

material—the conidial stage; hence it is sometimes called Downy Mildew. The conidia are blown about by the wind and distributed by other agencies, and under suitable conditions—moist weather—these conidia germinate and form infective tubes which pass through the stomata of the host plant.

Control.—1. Spraying with Burgundy or Bordeaux mixture on the first sign of this disease lessens the severity of the attack. Some material is necessary to cause the spray to adhere to the leaves, and resin is used for this purpose. Repeated applications at intervals of not more than seven days are essential when a young bed is affected.

2. Do not use infected land for growing onions.

Onion Smut (*Urocystis cepulæ*).

Life-history.—This is a disease of seedling onions, and the causal organism is said to persist in the soil for at least twelve years. Infection takes place from the soil, and affected seedlings either die soon after attack or else produce very poor bulbs. The leaves show dark opaque spots, the plants wilt, and a mass of black spores is formed on these black areas in the shape of sori. These masses fall to the ground, and the central spore germinates to form a branched hypha on which conidia are borne.

Control.—1. Proper rotation of crops will lessen the danger from this parasite.

2. Onions from onion sets and from transplanted onions are usually free from the disease, and where the land is infected the seedling stage should be passed elsewhere.

3. The disease has been controlled by dressing the seed with formaldehyde. This is done by means of a drip attachment on the seeding machine, or by wetting the rows with this solution before the seed has been covered. The formaldehyde is used at a dilution of 1 in 200, and as it takes about 200 gall. to dress an acre, 1 gall. of formaldehyde per acre should prove sufficient.

Black Spot or Scab of Onions (*Vermicularia circinans*).

Considerable loss in stored onions is sometimes due to this disease, which is much more noticeable in some seasons than in others. When the bulbs are attacked just before ripening and the crop can be quickly dried off, little damage results, but in moist districts or where the bulbs remain succulent for a long time their total decay may ensue.

Life-history.—Scattered black almost circular patches usually appear on the outside bulb scales. Black concentrates of mycelium may be seen arranged in concentric circles. The disease may start at the top of the bulb and pass down into the lower scales. The conidia are borne on conidiophores which burst through the affected membrane, and perithecia develop later.

Control.—All onions should be dried off quickly, and artificial drying s the best method of arranging for this.

Neck Rot or Grey Mould of Onions (*Botrytis alii*).

Life-history.—This causes serious loss to the onion grower, chiefly to the stored onions. On the leaves can be observed small white spots surrounded by a yellowish coloration which later turns brown. On the neck a grey furry mould which spreads to the bulbs is seen, and on the bulbs roundish black sclerotia appear. The bulb often rots, and this s possibly due to the entrance of bacteria. Mycelium is usually present between the scales of the bulbs.

Control.—1. No efficient method of control has been found, but the spraying of the crop with 1-per-cent Bordeaux mixture three or four times during the season from July onwards has given a certain measure of success.

2. The ripening of the crop should be hastened as much as possible, and the onions should be dried off thoroughly.

3. Seed disinfection as for *Onion Smut* should be tried.

Celery Heart Rot (*Sclerotinia sclerotiorum*).

This disease causes the plants to rot at or near the ground-level, and the fungus causing the disease attacks numerous plants, often occasioning serious loss in cabbage, tomatoes, and chrysanthemums.

The disease first appears as a white mould at the ground-level, the eaves turn yellow, and the plant dies. The stem decays, and numerous black sclerotia about the size of a pea may be found embedded in the tissue. These sclerotia germinate the following year to renew infection.

No curative measures are known. Fresh stable manure favours the disease.

Celery Early Blight (*Cercospora apii*).

Life-history.—This affects celery, parsley, and parsnips, and results in the partial or total destruction of the leaves. The older leaves show the disease first, and on them may be seen yellowish irregular areas visible from both sides of the leaf. These areas may coalesce to occupy the whole space between the veins of the leaf. The spots turn yellow or brown and the leaves wilt. Spores are produced on the brown spots and these spread the disease.

Control.—Spraying with ammoniacal copper carbonate or Bordeaux mixture is effective when commenced early, and several applications should be given.

Celery Late Blight (*Septoria petroselini*).

Life-history.—The disease manifests itself at first by the production

of scattered brown spots on the lower side of the leaves, and these spots later spread rapidly until the whole leaf is affected and wilts and dies. The disease can pass very quickly along a row and may ruin large quantities of celery. The affected areas show numerous black pycnidia, especially on the older leaves. The disease spores winter in the rubbish and in the soil.

Control.—1. Rotation of crops.

2. Seed disinfection.

3. As a prevention, spray with Bordeaux mixture the nursery bed or transplanting box. Two later applications are necessary.

Bacterial Soft Rot of Vegetables (*Bacillus carotovorus*).

A very serious rot of growing and stored vegetables is due to the bacterium mentioned above, which results in a wet rot of the plant or plant part. According to the plant attacked, the affected part varies in colour from a light reddish brown to a very dark brown, and the diseased area is soft and may smell strongly. It usually turns the flower of the cauliflower a dark brown and causes it to decay, but may also induce decay in the interior of the stem.

In turnips and carrots the rot spreads from the base of the leaves down through the fleshy root.

Control.—Collect and burn all affected plants and adopt a rational rotation.

INDEX

Aberdeen Green Top Yellow turnip, ii, 85.
Abundance oat, i, 150.
— potato, ii, 50.
Aleppo grass, iv, 143.
Alfalfa, iii, 31, 215.
Ally potato, ii, 55.
America potato, ii, 53.
American gooseberry mildew, iv, 302.
Ammoniacal copper carbonate, iv, 294.
Amos's Early Bird hop, iv, 63.
Anbury, ii, 226.
Anthracnose, iii, 302.
Antler Moth, i, 341.
Aphis, i, 350.
Apple bitter rot, iv, 295.
— brown rot, iv, 296.
— canker, iv, 295.
— mildew, iv, 296.
— scab, iv, 297.
Apples, iv, 227.
— Diseases of, iv, 236.
— Insect pests of, iv, 236.
— Varieties of, iv, 229.
Archer barley, i, 208.
Archer Goldthorpe barley, i, 212.
Area under green crops, ii, 74.
— under turnips, ii, 73.
Arran Chief potato, ii, 57.
Arran Comrade potato, ii, 55.
Artichokes, iv, 280.

Banner oat, i, 150.
Barley, i, 198.
— Area under Cultivation of, i, 212.
— Characteristics of, i, 208.
— Classification of, i, 199.
— Commercial Valuation of, i, 218.
— Cost of Growing, i, 246.
— Fungous Diseases of, i, 331.
— Imported Varieties of, i, 207.
— Manuring of, i, 220.
— Products of, i, 248.
— Soils and Climate favourable to, i, 216.
— Yield of, i, 241.
Bean Aphis, i, 351.
Bean Aphis Beetle, i, 352.
— Weevil, i, 354.
Beans, Characters of, i, 272.
— Cost of Growing, i, 277.
— Field, i, 273.
— Foreign, i, 280.
— Garden, i, 274.
— Java, i, 280.
— Kidney, i, 274.
— Locust, i, 280.
— Products of, i, 281.
— Runner, i, 274.
— Soya, i, 280.
— Varieties of, i, 273.
Bedstraw, Yellow, *iii, 118*.
Beet, Diseases of, ii, 226.
— Wild, i, 4.
Beet Carrion Beetle, ii, 298.
— eelworm, ii, 301.
— mildew, ii, 232.
— pulp, ii, 156.
— rust, *ii*, 230.
Beetle grubs, ii, 276.
Belgian Red Willow, iv, 92.
Benefactor wheat, i, 99.
Bent, iv, 204.
— Black, iii, 5.
— Brown, iii, 5, 8.
— Common, iii, 5, 10.
— White, iii, 8.
Berlie oat, i, 153.
Beseler's Prolific oat, i, 151.
Best-of-All swede, ii, 85.
Bilberry, iii, 82.
Bindweed, iii, 118.
— iv, 191, 210.
Black Bell oat, i, 153.
Black Heart, ii, 270.
Black-leg, ii, 249.
Black Maul willow, iv, 91.
Black Medick, iv, 146.
Black Mesdag oat, i, 153.
Black rot, ii, 234.
— scab, ii, 246.
Black Tartarian oat, i, 152.

Black Winter oat, i, 154.
Blainslie oat, i, 154.
Blight, i, 328; ii, 240.
Blue Pryor tobacco, iv, 102.
Bokhara, iv, 146.
Bordeaux mixture, ii, 41, 243; iv, 293.
Botrytis disease, ii, 267.
Bountiful oat, i, 153.
Bracken, iv, 198.
Bramling hop, iv, 63.
British Queen potato, ii, 55.
Broccoli, iv, 285.
Brome, Soft, iii, 5, 15.
— Upright, iii, 6, 14.
Brooker's Double Standup wheat, i, 100.
Broom corn, iv, 139.
Browick Grey Chaff wheat, i, 101.
Brown Merrins osier, iv, 91.
Brown scab, ii, 262.
Brussels Sprouts, iv, 286.
Buckwheat, iv, 113.
Bugle, Common, iii, 119.
Bugs, ii, 295.
Bullock turnip, ii, 85.
Burgundy mixture, ii, 41, 244; iv, 293.
Burnet, Greater, iii, 114.
— Salad, iii, 42.
Bush fruit, iv, 241.
Butcher system of hop growing, iv, 70.
Buttercup, Bulbous, iv, 217.
— Corn, iv, 215.
— Creeping, iv, 215.
— Upright, iv, 216.
Buttercups, iii, 117.

Cabbage, iv, 283.
— black rot, iv, 304.
— crop, ii, 163.
— stem rot, iv, 305.
— Wild, i, 4.
Cabbages, Composition of, ii, 208.
— Diseases of, ii, 226.
— Early, ii, 164.
— Late, ii, 165.
— Manuring of, ii, 169.
— Midseason, ii, 165.
— Yield of, ii, 170.
Canker, ii, 226.
Canterbury Whitebine hop, iv, 64.
Captain oat, i, 151.
Carrot rust maggot, ii, 303.
Carrot, Wild, iii, 117; iv, 222.
Carrots, ii, 195.
Caterpillars, ii, 291.
— False, ii, 294.
Cat's Ear, iii, 118; iv, 189.
Cauliflower, iv, 284.
— disease, ii, 246.
Celery, iv, 269.
— early blight, iv, 307.
Celery, heart rot, iv, 307.
— late blight, iv, 307.
Centenary turnip, ii, 84.
Champion potato, ii, 56.
Champions osier, iv, 91.
Change of Seed (Oats), i, 165.
Charlock, iv, 193.
Chevallier barley, i, 209.
Chickweed, iii, 119; iv, 173, 175.
Chicory, iii, 40; iv, 109.
Cigar tobacco, iv, 102.
Cigarette tobacco, iv, 102.
Clamp, ii, 46.
Cleavers, iv, 218.
Clemrothry oat, i, 153.
Clover, Alsike, iii, 34, 165, 256.
— Annual White Sweet, iv, 147.
— Biennial White Sweet, iv, 146.
— Composition of, iii, 207.
— Crimson, iii, 220, 258.
— Diseases of, iii, 300.
— Hubam, iv, 147.
— Red, iii, 32, 157, 254.
— Seed production of, iii, 254.
— Swedish, iii, 32.
— Sweet, iv, 146.
— White, iii, 35, 162, 256.
— Yellow Suckling, iii, 37.
— Yellow Sweet, iv, 147.
Clovers, iii, 32, 190.
Club root, iv, 304.
Cobb's hop, iv, 63.
Cockchafer, i, 339.
Cocksfoot, iii, 16, 150, 260.
Colegates hop, iv, 64.
Colorado Beetle, ii, 277.
Coltsfoot, iv, 179.
Comfrey, iv, 147.
Commerson's potato, ii, 9.
Common Mallow, iii, 114.
Competition, iii, 56.
Conqueror swede, ii, 86.
Continuous cropping, iv, 11.
— wheat growing, i, 115.
Copper King tobacco, iv, 102.
Copper sulphate, iv, 293.
Corky scab, ii, 259.
Corn Cockle, iv, 172.
Corn-flower, iv, 183.
Corn Sowthistle, iv, 186.
Corrosive sublimate, iv, 294.
Cotton Grass, iii, 83.
Couch, iii, 4, 8.
— grass, iv, 202.
— Onion, iii, 5, 13.
Cowslip, iv, 214.
Crane's Bill, Cut-leaved, iii, 117.
— — Dove's Foot, iii, 114.
— — Meadow, iii, 114.
Creeping Thistle, iv, 184.

Crested Dogstail, iii, 7, 15, 156.
Cross Cropping, iv, 32.
Crown gall, ii, 235.
Crown oat, i, 151.
Crusader potato, ii, 56.
Cuckoo-flower, iii, 114; iv, 196.
Curly-leaf midge, ii, 290.

Daddy-long-legs, i, 342.
Daisy, iii, 118; iv, 181.
— Ox Eye, iii, 114.
Dandelion, iii, 115; iv, 190.
Danish Brattingsborg rye, i, 257.
Dargill Early potato, ii, 54.
Darwin's potato, ii, 9.
Dhu Back oat, i, 153.
Dicky Meadows osier, iv, 91.
Dipterous Enemies, iii, 286
Diseases, Seed-borne, iii, 238.
Dock, iv, 211.
Dodder, iv, 192.
Dog's Mercury, iii, 120.
Downs, iii, 93.
Downy mildew, ii, 232.
Dreadnought wheat, i, 104.
Dredge Corn, i, 265.
Dried Grains, i, 250.
Dropwart, Water, iii, 120.
Dry rot, ii, 264.
— scab, ii, 258.
— spraying, ii, 42.
Duke of York potato, ii, 54.
Durra, iv, 139.

Early Fellow oat, i, 153.
Earthnut, iii, 116.
Eclipse potato, ii, 54.
Eelworms, ii, 283; iv, 283
Elliot, iii, 174.
Ensilage, iv, 37.
Enterkin swede, ii, 85.
Epicure potato, ii, 54.
Ergot, i, 334; iii, 293.
Essex Conqueror wheat, i, 101.

Fallows, iv, 6.
Farnham Whitebine hop, iv, 64.
Felt-rot, Violet, iii, 306.
Fenman wheat, i, 100.
Fescue, Hard, iii, 18.
— Meadow, iii, 6, 20, 154, 262.
— Pastures, iii, 78.
— Red, iii, 6, 8.
— Sheep's, iii, 8, 18, 262.
— Tall, iii, 6, 21, 262.
Field Madder, iv, 219.
Fife, Burgoyne's, wheat, i, 99.
— *Red*, wheat, i, 104.
Finger-and-toe, ii, 26.
Flax, iv, 123.
Fleabane, iii, 118.
Flea beetles, ii, 277, 285.
Formalin, iv, 294.
Fosterton Hybrid turnip, ii, 85.
Fox wheat, i, 101.
Foxtail, Floating, iii, 5, 11.
— Meadow, iii, 5, 262.
— Slender, iii, 5, 11.
French osier, iv, 91.
Frit Fly, i, 349.
Fruit, Diseases of, iv, 289.
— growing, iv, 225.
Fuggle's hop, iv, 64.
Fungi, i, 318.
Fungicides, iv, 292.
Fungous diseases of Barley, i, 331.
— diseases of Oats, i, 329.
— diseases of Wheat, i, 313.
Furze, iv, 150.

Garden Chafer, i, 340.
Garden Swift Moth, ii, 279.
Garlic, iii, 115.
Geranium, Cut-leaved, iv, 200.
— Dove's Foot, iv, 199.
Germans osier, iv, 91.
Germination Test, iii, 279.
Glibskins osier, iv, 91.
Golden Drop wheat, i, 101.
Golden Oat, iii, 5.
Golden Rain oat, i, 151.
— willow, iv, 92.
— *Wonder* potato, ii, 56.
Gold Finder oat, i, 152.
Goldstones osier, iv, 91.
Goldthorpe barley, i, 209.
Gooseberry die-back, iv, 301.
Goosefoot, iv, 175.
Gorse, iv, 150.
Gout Fly, i, 347.
Grain Crops, Cost of Production of, i, 303.
— — Insect Enemies of, i, 337.
Gram bean, i, 280.
Grass, Composition of, iii, 207.
— Diseases of, iii, 288.
— Seed Production of, iii, 254.
Grasslands, Manuring of, iii, 127, 142.
— Natural, iii, 77.
— Semi-natural, iii, 92.
— Tended, iii, 108, 120.
Great Scot potato, ii, 55.
Green Fly, ii, 295.
Green osier, iv, 91.
Green Top White turnip, ii, 84.
Green Top Yellow turnip, ii, 85.
Greenweed, iii, 116.
Grey mould, iv, 303.
Greystone turnip, ii, 84.
Ground Beetles, ii, 298.

Groundsel, iv, 178.
Guinea grass, iv, 137.

Halewood swede, ii, 86.
Halliday tobacco, iv, 102.
Hamilton oat, i, 153.
Harvester wheat, i, 101.
Hawkbit, Autumnal, iii, 118; iv, 188.
— Rough, iii, 115; iv, 188.
Hawk wheat, i, 103.
Hay, Composition of, iii, 208.
— crop, iii, 178.
— *Feeding Value of, iii, 199.*
— Manuring for, iii, 130.
Heather, *iii, 82; iv, 129.*
— burning, iv, 133.
Heath Grass, Blue, iii, 28.
— — Purple, iii, 5, 23.
Hemlock, iii, 120.
Hemp, iv, 104.
— Giant, iv, 104.
— Great, iv, 104.
— *Manila, iv, 104.*
— Mauritius, iv, 104.
— New Zealand, iv, 104.
— Sisal, iv, 104.
— Small, iv, 104.
Hero oat, i, 152.
Hessian Fly, i, 346.
Hogg Weed, iii, 114.
Hollow heart, *ii, 271.*
Hopetoun oat, i, 153.
Hop canker, iv, 87.
— mould, iv, 83.
— oast, iv, 77.
— picking, iv, 75.
Hops, iv, 59.
— Cultivation of, iv, 64.
— Diseases of, iv, 83.
— Distribution of, iv, 64.
— Early varieties of, iv, 63.
— Late varieties of, iv, 64.
— Manuring of, iv, 73.
— Mid-season varieties of, iv, 63.
— Packing of, iv, 81.
— Preparation of land for, iv, 65.
— Propagation of, iv, 66.
— Virus diseases of, iv, 88.
Horsetail, iv, 197.
Hybridization, i, 44.
Hybrids, Utilization of, i, 51.

Immune Ashleaf potato, ii, 53.
Insect Enemies of Pasture Plants, iii, 283.
Insects, ii, 272.
Irish Gold tobacco, iv, 102.

Jersey Kale, ii, 185.
John Bull wheat, i, 101.
Johnson grass, *iv, 139.*

Kafir Corn, iv, 139.
Kale, *ii, 185.*
— Composition of, ii, 208.
— Diseases of, ii, 226.
Katie Glover potato, ii, 55.
Kentucky Black tobacco, iv, 102.
Kerr's Pink potato, ii, 57.
King Edward VII potato, ii, 57.
— *George V* potato, ii, 55.
Knapweed, *iii, 114; iv, 186.*
Knecks osier, iv, 91.
Kohl-rabi, ii, 173.
— *Composition of, ii, 207.*
— Diseases of, ii, 226.

Lady's Bedstraw, iv, 216.
— Mantle, iii, 117.
Langworthy potato, ii, 56.
Latakia tobacco, iv, 102.
Lazy-bed system of potato growing, ii, 28.
Leader oat, i, 151.
Leaf Curl, ii, 252.
— Spot, i, 333.
Leguminosæ, iii, 29.
Leguminous plants, iv, 143.
Lepidopterous enemies, iii, 284.
Ley, iii, 43.
— Out-run, iii, 97, 108.
Lime, iii, 130.
Ling, iv, 129.
Linseed, iv, 123.
— crop, Enemies of, iv, 128.
— Varieties of, iv, 123.
Literature of Pastures, *iii, 134.*
Little Joss wheat, i, 101.
Long Bud osier, iv, 91.
Longhoughton oat, i, 154.
Longskins osier, iv, 91.
Lucerne, iii, 31, 215, 259.
— Diseases of, iii, 297.
— Yellow, iv, 146.
Lupins, iv, 154.

Majestic potato, ii, 57.
Mangold crop, ii, 126.
Mangold Fly, ii, 299.
Mangolds, Composition and Nutritive Value of, ii, 140.
— Diseases of, ii, 226.
— Manuring of, ii, 129.
— Varieties of, ii, 131, 141.
Manures, Farmyard, i, 121.
— Nitrogenous, i, 118, 170.
— Phosphatic, i, 119, 169.
— *Potassic, i, 120, 169.*
Maritime Swards, iii, 89.
Marquis wheat, i, 103.
Marrow-stem Kale, ii, 191.
Marshal Foch wheat, i, 102.
Martin wheat, i, 102.

Marvellous oat, i, 152.
Mass Selection, i, 40.
Mat Grass, iii, 8, 24.
Mathon hop, iv, 63.
Mawdsley osier, iv, 91.
Meadow *Foxtail, iii,* 5, 10, 155.
Meadow Grass, Annual, iii, 7, 25.
— — Rough-stalked, iii, 8, 27, 155, 263.
— — Smooth-stalked, iii, 7, 26, 155, 263.
— — Wood, iii, 7, 26.
Meadow *Saffron, iii,* 115.
— Sweet, iii, 116.
Meadow, Water, iii, 112, 193.
Mealy Top osier, iv, 91.
Medicago Spp., iii, 30.
Medick, Purple, *iii,* 31.
Melilot, iv, 146.
Mendel's Law, i, 17.
— Modifications of, i, 23.
Mildew, i, 326, 329.
— Downy, iii, 306.
— Powdery, iii, 293.
Milfoil, iii, 39.
Millet, iv, 135.
— Common, iv, 137.
— Farmyard, iv, 137.
— Green, iv, 138.
— Italian, iv, 137.
— Pearl, iv, 138.
Millipedes, ii, 281.
Milo, iv, 139.
Mites, ii, 282.
Mosaic Disease, ii, 256.
Mosses, iii, 117.
Mounted Police oat, i, 151.
Multihybrid Ratio, i, 22.
Mustard, iv, 118.
— Beetle, ii, 287.
— Brown, iv, 118.
— White, iv, 120.
Mutation, i, 15, 38.

Net necrosis, ii, 270.
Nettle, iii, 119; iv, 223.
Newmarket oat, i, 151.
Nipplewort, iv, 187.
Nurse crop, iii, 50, 140.

Oat Grass, Golden, iii, 28.
— Tall, iii, 5, 12, 262.
Oat, Grey, iv, 201.
— Shetland, iv, 201.
Oatmeal, i, 186, 195.
Oats, Acreage under, i, 140.
— Best Soils for, i, 137.
— Classification of, i, 138.
— Close-eared, i, 138.
— Cost of growing, i, 184.
— Electrolytic Treatment of, i, 168.
— Fungous *Diseases of, i,* 329.
Oats, Grain Producers, i, 144, 150.
— Imported, i, 195.
— Manuring of, i, 169.
— Milling Properties of, i, 154.
— Offals of, i, 196.
— Open-eared, i, 140.
— Potato (oat), i, 139, 153.
— Products of, i, 188.
— Straw Producers, i, 148, 153.
— Suitable Climate for, i, 156.
— Tartarian, i, 138.
— Varieties of, i, 143, 153.
— Wild, i, 133; iv, 201.
— Yield of Straw of, i, 183.
Onion Couch, iii, 5.
— *mildew, iv,* 305.
— scab, iv, 306.
— smut, iv, 306.
Onions, iv, 253.
Orchards, Improvement of, iv, 245.
Orchids, iii, 115.
Osiers, iv, 90.
— Classification of, iv, 91.
Ox-eye Daisy, iv, 177, 178.

Palatability of Grasses, iii, 123.
Parsley, Beaked, iii, 114.
— Sheep's, iii, 40.
Parsnip Maggot, ii, 344.
Parsnips, ii, 200.
— Composition of, *ii,* 211.
— Manuring of, ii, 201.
— Varieties of, ii, 200.
— Yield of, ii, 202.
Partridge wheat, i, 102.
Pasture, Dairy, iii, 110.
— Fattening, iii, 109.
— General, iii, 111.
— Mat Grass, iii, 79.
— Molinia, iii, 80.
— Water-logged, iii, 96.
Pea and Oat hay, iii, 192.
Pea, Grass, iv, 145.
— Narrow-leaved, iv, 145.
Pea Midge, i, 354.
— Moth, i, 355.
— Weevil, i, 354.
Pear leaf spot, iv, 298.
— scab, iv, 298.
Pearl grass, iv, 202.
Pears, *iv,* 238
Peas, i, 284.
— Acreage under, i, 285
— Characters of, i, 286.
— Cost of growing, i, 291.
— Field, i, 287.
— Garden, i, 288.
— Products of, i, 293.
— Varieties of, i, 287.
Percival's Blue Cone wheat, i, 104.

Petham Golding hop, iv, 64.
Petkus rye, i, 257.
Phloem necrosis, ii, 252.
Phoma rot, ii, 236.
Pigmy Mangold Beetle, ii, 299.
Pink rot, ii, 251.
Pipe tobacco, iv, 102.
Plantain, iii, 41, 118.
Plover wheat, i, 102.
Plumage barley, i, 209.
Plum brown rot, iv, 300.
— pockets, iv, 299.
Plums, iv, 239.
Pomeranian White Globe turnip, ii, 84.
Poppy, iv, 209.
Potato bug, ii, 280.
— crop, ii, 9.
— crop, Early, ii, 1.
— diseases, ii, 239.
— Frog Fly, ii, 280.
Potatoes, Acreage of, ii, 11.
— Change of Seed of, ii, 35.
— Composition and Products of, ii, 59.
— Cost of Production of, ii, 218.
— Distribution of, ii, 12.
— Dried, ii, 66.
— Field Cultivation of, ii, 18.
— Harvesting of, ii, 43.
— Manuring of, ii, 28.
— Nutritive Value of, ii, 65.
— Quality of, ii, 21.
— Storage of, ii, 45.
— Varieties of, ii, 48, 53.
— Yield of, ii, 14, 45.
Powdery Mildew, ii, 233.
President potato, ii, 58.
Prolific hop, iv, 63.
Pure Lines, i, 16.
Purging Flax, iii, 116.
Purple Top Mammoth turnip, ii, 84.
— *Top Yellow* turnip, ii, 85.

Quaking Grass, iii, 5, 14.
Quality in Wheat, i, 110.

Ragged Robin, iii, 114.
Ragwort, iii, 117; iv, 181.
Rape, ii, 179.
— Beetle, ii, 286.
— Composition of, ii, 209.
— Diseasea of, ii, 226.
Raspberries, iv, 262.
Record oat, i, 152.
Red Admiral wheat, i, 104.
Red Bartsia, iii, 118.
Red Buds osier, iv, 91.
— *Globe* turnip, ii, 84.
— *Marvel* wheat, i, 104.
Redshank, iv, 211.
Red Standup wheat, i, 102.
Reed Mace Disease, iii, 294.
Rest-harrow, iv, 208.
Rhizoctonia disease, ii, 237, 268.
Rhoderic Dhu potato, ii, 57.
Rihgrass, iii, 41.
Ribwort, iii, 41.
Rodmersham Golding hop, iv, 64.
Root rot, ii, 236.
Rotations, Eight-course, iv, 28.
— Five-course, iv, 18.
— History of, iv, 1.
— Principle underlying, iv, 9.
— Seven-course, iv, 25.
— Six-course, iv, 22.
— Two-, Three-, and Four-course, iv, 11.
Runch, iv, 194.
Rushes, iii, 3, 117, 119; iv, 206.
Rust, ii, 271; iii, 288, 291, 296, 297.
— Black, i, 319, 330, 333.
— Brown, i, 322, 335.
— Crown, i, 330.
— Yellow, i, 321, 333.
Rustic Moth, i, 342.
Rye, i, 253.
— Fungous Diseases of, i, 334.
— Mammoth White, i, 275.
— Midsummer, i, 258.
— Rosen, i, 257.
— White Russian, i, 257.
— Winter, i, 257.
— Varieties of, i, 256.
Ryegrass, iii, 259.
— Italian, iii, 6, 23, 148.
— Perennial, iii, 7, 22, 144.

Sainfoin, iii, 209, 259.
— Diseases of, iii, 297.
Salt Marshes, iii, 90.
Samos tobacco, iv, 102.
Sandy oat, i, 153.
Savoy, iv, 289.
Scab, ii, 232.
Scentless Mayweed, iv, 177.
Sclerotium disease, ii, 237, 266.
Sedges, iii, 117.
Seed, Legislation in respect of, iii, 273.
— production, iii, 230.
— Quality of, iii, 272.
— testing, iii, 230.
Seeds mixtures, iii, 59, 60, 71, 166.
— — Choice of, iii, 53.
Selection and disease resistance, i, 35.
— and pedigree breeding, i, 25.
— applied to herbage plants, i, 33.
— within pure lines, i, 37.
Self Heal, iii, 119; iv, 208.
Sensation wheat, i, 104.
Septoria Disease, iii, 295.
Serradella, iv, 147.
Sharpe's Express potato, ii, 54.

Sheepfold turnip, ii, 84.
Sheep's Sorrel, iv, 212.
Shepherd's Kale, ii, 185.
— Purse, iv, 195.
Silage, Advantages of making, iv, 38.
— Composition of, iv, 52, 53, 54.
— Crops suitable for, iv, 50.
— Methods of making, iv, 41.
— Trench system of, iv, 48.
Silos, Brick, iv, 43.
— Capacity of, iv, 44.
— Concrete, iv, 42.
— Deep pit, iv, 47.
— Essentials of, iv, 47.
— Hoard, iv, 43.
— Tower, iv, 41.
— Wooden, iv, 43.
Silver leaf, iv, 299.
— scurf, ii, 258.
— Weed, iii, 117; iv, 217.
— Y Moth, ii, 299.
Sir Douglas Haig oat, i, 152.
Skin Spot, ii, 270.
Skirving swede, ii, 86.
Slaters, ii, 281.
Slugs, ii, 282.
Smooth Heath Grass, iii, 6.
Smut, iii, 292.
— Loose, i, 325.
— Oat, i, 329.
— Stinking, i, 323.
— Wheat, i, 323.
Snakes Weed, iii, 115.
Snowdrop wheat, i, 100.
Soft Brome, iv, 204.
— Crepis, iii, 116.
Sorghum, iv, 138.
— Broom, iv, 142.
— Forage, iv, 142.
— Grain, iv, 141.
— Sugar, iv, 141.
Sorgo, iv, 139.
Sorrel Dock, iii, 119; iv, 213.
— Sheep's, iii, 119; iv, 212.
Spear Thistle, iv, 183.
Speedwell, iii, 118.
Spindly sprout, ii, 270.
Spratt-Archer barley, i, 211.
Spratt barley, i, 210.
Spraying of Potatoes, ii, 41.
Spreading Orache, iv, 176.
Springtails, ii, 301.
Spurry, iv, 174.
Squarehead Master wheat, i, 102.
Standard Red wheat, i, 102.
Standup White wheat, i, 100.
Standwell barley, i, 211.
Starling wheat, i, 100.
Stebler, iii, 171.
Stemless Thistle, iv, 185.
Stonerods osier, iv, 91.
Storm King oat, i, 152.
Stormproof wheat, i, 103.
Strawberries, iv, 246.
Strawberry leaf spot, iv, 304.
— mildew, iv, 303.
Stripe Disease, i, 332; iii, 295.
Succory, iii, 40.
Sugar beet, ii, 147.
— — Composition of, ii, 205.
— — Curly top of, ii, 231.
— — Diseases of, ii, 226.
Sunflower, iv, 152.
Supreme oat, i, 152.
Surface caterpillars, ii, 278, 305.
Swan wheat, i, 102.
Swedes, ii, 85.
Swedish Iron wheat, i, 102.
Sweet Vernal Grass, iii, 4, 11.

" Take-all ", i, 327.
Tall Fescue, iii, 5.
— Oat Grass, iii, 5, 12, 156.
Tam Finlay oat, i, 154.
Tare from Beet, ii, 155.
Tares, iii, 223.
Teasel, iv, 148.
Thistle, Boar, iii, 116; iv, 183.
— Carline, iii, 116.
— Creeping, iii, 116; iv, 184.
— Marsh, iii, 116.
— Stemless, iii, 116; iv, 185.
Thousandhead Kale, ii, 185.
Thrips, i, 351.
Timothy, iii, 6, 24, 153, 180, 261.
Tinwald Perfection potato, ii, 57.
Tobacco, iv, 96.
— Diseases of, iv, 102.
— Varieties of, iv, 102.
Tolhurst hop, iv, 63.
Trefoil, iii, 39, 166, 191, 258.
Trifolium, iii, 220.
Tufted Hair Grass, ii, 6, 17.
Tunis grass, iv, 139.
Turnip Aphides, ii, 296.
— crop, ii, 69.
— Gall Weevil, ii, 287.
— Leaf Miner, ii, 290.
— Mud Beetle, ii, 288.
— Root Maggot, ii, 289.
Turnips, Composition and Nutritive Value of, ii, 119.
— Diseases of, ii, 225.
— Distribution of, ii, 75.
— Manuring of, ii, 97.
— Methods of Storing, ii, 113.
— Singling of, ii, 109.
— Types of, ii, 78.
— Varieties of, ii, 80.
— White, ii, 84.

Turnips, Yellow, ii, 84.
— Yield per acre of, ii, 114.
Tutsham hop, iv, 63.

Umbrella system of hop growing, iv, 68.
Universal wheat, i, 103.
Up-to-Date potato, ii, 58.

Variations, i, 13.
— Classification of, i, 24.
Vegetables, Diseases of, iv, 289.
Verticillium disease, ii, 265.
Vetch and Grain mixture, iii, 191.
Vetch, Bush, iv, 144.
— Chickling, iv, 145.
— Hairy, iv, 144.
— Kidney, iii, 38, 258.
— Siberian, iv, 144.
Vetches, iii, 223.
Vetchlings, iv, 145.
Victor wheat, i, 100.
Victory oat, i, 151.

Wart disease, ii, 246.
Waverley oat, i, 152.
Wavy Hair Grass, iii, 8, 17.
Weeds, iv, 158.
— Methods of extermination, iv, 168.
Welch osier, iv, 91.
Wheat, i, 59, 64.
— Acreage under, i, 92.
— Canadian, i, 103.
— Climate for, i, 65.
— Comparative Yields of, i, 105.
— French, i, 104.
— Fungous Diseases of, i, 313.
— Manuring of, i, 84.
— Products of, i, 126.
— Quality in, i, 110.
— Red, i, 101.
Wheat, Rivet, i, 105.
— Soils for, i, 67.
— Spring sown, i, 80.
— Varieties of, i, 98.
— White, i, 99
Wheat Bulb Fly, i, 348.
— Midge, i, 347.
— Offals, i, 129.
— Straw, i, 131.
Whin, iv, 150.
Whissenders osier, iv, 91.
White Campion, iv, 171.
White Globe turnip, ii, 84.
White Grub, ii, 265.
White Horse oat, i, 150.
White Queen wheat, i, 100.
White rot, ii, 229.
— rust, ii, 232.
White Waterloo oat, i, 150.
Wide Awake oat, i, 150.
Wild Radish, iv, 194.
Wilhelmina wheat, i, 100.
Willows, iv, 90.
— Yields and returns from, iv, 94.
Wireworms, i, 337.
Witchhill potato, ii, 54.
Woodlice ii, 272, 281.
Woodrush, iv, 207.
Worcester system of hop growing, iv, 69.

XL All swede, ii, 86.

Yarrow, iii, 39, 118.
Yellow Mammoth tobacco, iv, 102.
— *Orinoco* tobacco, iv, 102.
Yellow Rattle, iii, 115; iv, 221.
Yeoman wheat, i, 103.
Yielder oat, i, 152.
Yorkshire Fog, iii, 5, 21; iv, 205.

Agricultural College Library
No. 1574
13 AUG 1927
COIMBATORE